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SURFACE FEATURES OF THE MOON, THE EARTH, AND MARS.

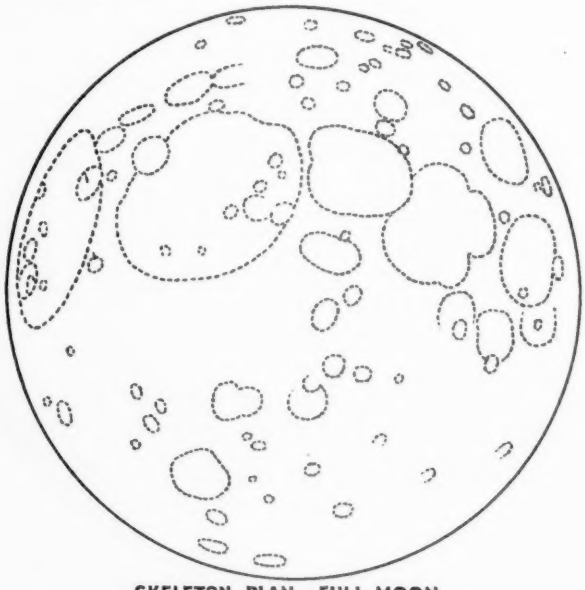
By JOHN MILLIS.

Upon a review of the various theories and speculations that have been offered to account for the observed surface features or topographic details of the moon, it is found that one or both of two main ideas—volcanic action and impact by meteors—can be traced through practically all of them and that these always appear as more or less conflicting and inconsistent, even when attempts have been made to utilize both in the same general presentation. It is somewhat remarkable that the two hypotheses both find much supporting evidence that tends so strongly to confirm them, notwithstanding their seeming radical differences; one being based entirely on internally acting forces and the other on causes originating wholly external to the satellite. Why should two so diametrically opposed theories each be able to point to observed facts that seem so consistent and confirmatory? Is there not perhaps something especially significant about this apparent anomaly, and is it possible to find some better reconciliation of the two conceptions or even to harmonize them into a more completely satisfying explanation than has heretofore been offered?

Thanks to the developments in astronomical instruments and the art of photography, it is now practicable for those who have neither the facilities nor the skill that are available only to specially trained and experienced astronomical observers, to make intelligent studies of the details of the moon's surface. Perhaps there is a real advantage to the expansion of knowledge in thus opening the subject to an increased number of the curious, most of whom will be free from the predilections and preconceived notions that sometimes find lodgment in the minds of special students. Moreover a degree of incidental assistance in interpreting lunar photographs can now be derived from experience in the fast developing field of airplane photography, resulting from checking up aerial views with the actual surface details of areas on the earth that have been depicted by this process.

The well known mottled appearance of the face of the full moon as recognized by ordinary unassisted eyesight is easily resolved by a field glass or small telescope into dark irregular patches that seem to be fairly smooth, and lighter areas that in general are more rough and rugged. These main features are clearly shown on a good photograph

of the full moon made by modern improved apparatus. Looking for a general plan of these markings it is at once recognized that the greater portions of the dark smooth areas have more or less well defined circular outlines. Some of the boundaries are complete circles, while others are made up of detached circular arcs and are rather fragmentary. In fact if we were to take a large ball or plain globe and undertake to lay out on it a diagrammatic outline or framework for a complete sketch plan of the principal features of the moon's visible surface, such a framework could be very largely constructed with ordinary compasses or dividers. The dark or smooth areas are within the circles and arcs, and the remaining portions outside are rougher and brighter.



SKELETON PLAN – FULL MOON

Now pass from the general sketch plan to some of the details. The elements of circles are found to persist in a remarkable degree and they are extraordinarily numerous. Bounding the smooth plain areas are portions of circles or arcs with diameters as great as six hundred or seven hundred miles, and there are well defined complete circular plains from over three hundred miles across down to little round patches not too easy to recognize on the best photographs. These circular areas with plain floors merge gradually into the round pits or craters characterized by relatively higher and more continuous bounding walls, often rudely terraced, with floors that are generally more

uneven, changing in the smaller ones to a hollow or bowl shape, and frequently having a central pinnacle. In size these distinct craters are of all diameters from 86 miles to less than a mile, and there are minute specks barely recognizable by the most powerful instruments, or on the most detailed pictures available, which are quite certainly pits of the same character. These craterlike pits are numbered by the thousands and they crowd, encroach upon, and override each other in the greatest imaginable confusion.

All these circular forms blend by almost imperceptible degrees one into the other, from the biggest to the smallest, but certain characteristic differences should be noted in the surroundings of the dark patches. The boundaries for the largest patches are always somewhat broken and fragmentary, with incomplete circular arcs showing sometimes ranges and scattered peaks constituting what have been termed mountain chains, and the larger examples of the completely enclosed circular dark areas have bounding limits that are more broken and irregular and less continuous than obtains for those of the smaller sizes. In case of these latter and of the majority of the craters or pits of all sizes the enclosing rims show a tendency to maintain completeness and integrity, except where pits overlap or interfere one with another. Besides the above broad features we find many details in the way of clefts or grooves, deep canyons, terraces in the walls of pits and plain areas, ridges, streaks, and markings of various patterns. Some of these have been very perplexing under all the theories yet proposed.

Coon Butte pit, near Canyon Diablo, Arizona. Diameter 4000 feet; depth below top of rim 600 feet. From a model. Dr. George P. Merrill, curator, Department of Geology, U. S. National Museum, Washington.

The principal support for the volcanic theory is found in the striking similarity in shape between the pits or craters on the moon and certain volcanic craters on the earth, though no such terrestrial feature approaches in size the larger of the lunar craters, and the examples to

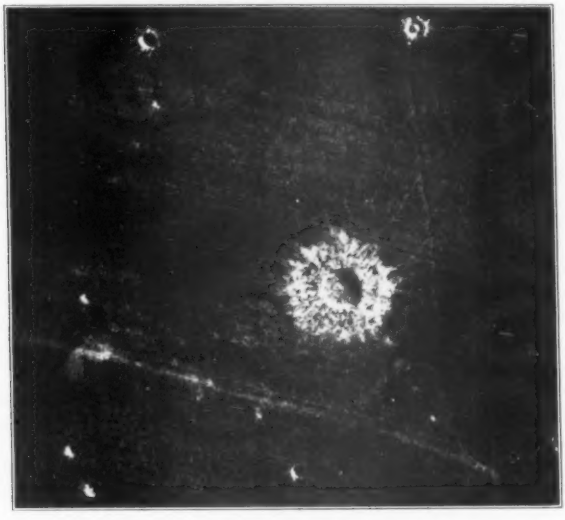
be found on our globe are not as uniformly and truly circular as are those of the moon. The general appearance of the smooth areas and certain relatively low ridges or swells of great length that are seen on these surfaces also strongly favor the volcanic explanation. These seem to leave no doubt that something like vast outflowing and overspreading of lava was the cause, and that this has occurred not only on the greater plains and circular areas, but in many of the smaller ones, and in some of the circular pits generally classed as craters. One remarkable instance is a circular area 53 miles across (Wargentin) that looks as though it was formed as a depression that has been filled with lava to the very top of its inclosing elevated rim.

The theory that the features described were formed by impact of meteors or external masses has in its favor the uniformly circular shape of the craters and pits and the striking resemblance between them and depressions that have been produced by various artificial means, as by dropping balls upon soft material, by impact of projectiles on steel armor, and quite recently by dropping explosive bombs to the ground from a balloon. The vast number of these pits on the moon, of all sizes, with their overlaps and superposition, also favors the meteor theory.

Effect of explosive Bombs dropped from Airplane.

The difficulties in the way of the volcanic theory are rather serious. First, how to account dynamically for the tremendous activity that such a vast number of volcanic craters, many of them of gigantic dimensions, would call for. Especially difficult is it to account for the circular

areas covered or floored with lava on this theory. The size of these compared to the diameter of the moon seems altogether too great to permit of any rational explanation on the assumption that all these circular areas are the remains of volcanic craters. One of the most clearly defined of these is the *Mare Crisium* (Sea of Crises), the dark oval spot that is readily seen by persons of ordinary good eyesight, very near the edge of the moon's disk in the upper right hand part when



Effect of explosive Bombs dropped from Airplane.

the moon is somewhat past the phase of new, and until it is full. This spot is rather more than three hundred miles in diameter and has an area about equivalent to that of the state of Missouri. The great area with a broken and approximately circular boundary, part of which is made up of mountain chains, designated as *Mare Serenitatis* (Sea of Serenity), has a diameter one third as great as that of the entire moon's disk—over 700 miles—and it would be sufficiently difficult to account for this as it now is by either of the above theories alone.

But if the great pits, quite certainly floored and partly or wholly filled with solidified lava, were not the result of some kind of volcanic action similar to such phenomena as known on the earth, then how could they have been formed? The meteor theory as heretofore presented seems altogether inadequate. On the other hand if the very numerous circular pits so exactly like those that are known to have resulted from the impact of one body, spherical in shape, (and sometimes supplemented by an explosive action) on the more or less yield-

ing surface of another, were in the case of the moon produced by an entirely different process, then what could this have been?

It would of course be possible for various quite different agencies to be the cause of the above different classes of circular forms on the moon's surface, and it would not seem inconsistent to seek such a variety of agencies *if the classes of these forms were sharply defined.* But they blend into each other in size and general character so gradually and have such a persistent tendency to a truly circular shape, as to suggest very strongly that there must be some general relation as to cause, underlying them all. What is this relation?

Disregarding for the present other theories as to the origin or history of the moon, suppose that we proceed to reconstruct it in imagination by the process of coalescence of constituent masses coming together solely under the influence of their mutual gravitational attraction and without other original relative movements. We will assume that the constituent elements start out as solid matter, but the heat developed by the impact and aggregation soon raises the growing mass to a temperature that will liquify at least considerable portions of it, and as it grows the aggregate becomes a spherical body with an outer solid crust or shell and an interior that has a high temperature and that is in part liquid matter like lava. The outer bodies continue to arrive and the growing process goes on. A very large spherical "meteorite" in striking penetrates the crust and is absorbed. This throws up a rim around a circular opening which corresponds to the diameter of the meteorite, or at least has some definite relation to it, and to its velocity upon impact, and the interior lava rises up and partly fills the depression forming a nearly level floor, or this floor may have resulted partly from melting of a portion of the matter directly involved in this particular encounter.

Here let it be especially noted that each arriving meteorite or external body is a contribution to the volume of our growing satellite, and that this requires *a corresponding extension of its surface.* The important significance of this point seems not to have been recognized in previous discussions of the subject. Circular areas originally formed as above are expanded; their boundary rims are stretched out and broken and they assume the forms of separated circular arcs of larger radius, or in places of straight lines. These areas may even be elongated, compressed to narrow valleys, or otherwise distorted. This may be compared to the effect on the lettering and pictures on the side of a child's rubber balloon when the balloon is inflated, or to the sentimental inscriptions and designs on the surface of a smooth barked tree trunk which becomes distorted with the growth of the tree.

The limit of height for protruding masses of solid matter on the moon's surface is conditioned by a gravitational force, the capacity of the material of such masses to resist crushing and crumbling, and the "angle of repose" or slope at which the material will stand. There

could have been no "weathering" like that which has had such an important influence in shaping the topography of the earth, since so far as known the moon has never had any atmosphere or water which would be essential for weathering effects, though some of the mountains or elevations which seem to be among the oldest forms show severe battering as by meteor impacts. The gravitational force must of course have increased as the moon grew in mass on the above assumptions, reducing the possible height for masses of a given material, and this will help explain the broken and degraded or tumbled-down aspect of some of the mountain ranges and separate peaks.

The forces of expansion due to the absorption of a constituent body may also cause cracks in the crust distant from the place of impact, with overflow of lava in vast sheets, and this may be repeated over and over again, partly or wholly submerging and destroying previously formed pits and crater rims (as evidenced in very numerous places on the photographs) and forming lava deposits in successive relatively thin layers. It is conceivable that the filling, partial or complete, of a rimmed depression made by the impact of an extraneous body, may be attributed to a similar later action elsewhere, rather than directly to the meteor or body that formed the depression. The outflow of lava by this process and the spread of the mass over a surface previously formed in a similar way accords with the long low ridges that are seen on the smooth areas of the moon, resembling somewhat the thin terminal edge of a sheet of water formed by waves running up a smooth sloping sand beach. Some of these ridges rather strikingly resemble meeting lines of two flowing lava sheets coming from opposite directions. The terraces around the walls of the pits strongly suggest the superposed sheets of lava. At a later stage, due to the thickening of the crust and possibly the smaller size of the impinging bodies or their lower velocity on impact, the crust is not penetrated but pits are formed exactly duplicating in shape and details those made by artificial processes already mentioned. The final act seems to have been a shower of a great number of smaller bodies, though some of the evidences of these may be attributed to the falling of small fragments that resulted from the general smash-up of larger masses on striking. Certain lines or grooves and the streaks radiating from some of the principal crater pits have so far defied a satisfactory explanation, though the possibility of fragments or bodies striking with a high velocity of revolution about a self contained axis might be given consideration. The immensely long straight streaks are especially mysterious. If these are due to some modification of the surface like a deposit of matter in considerable volume along an extended straight course, such a variation has too little height to be detected as yet, and the invisibility of the main streaks except at full moon adds to the puzzle.

The question of the origin or previous state of the moon will not

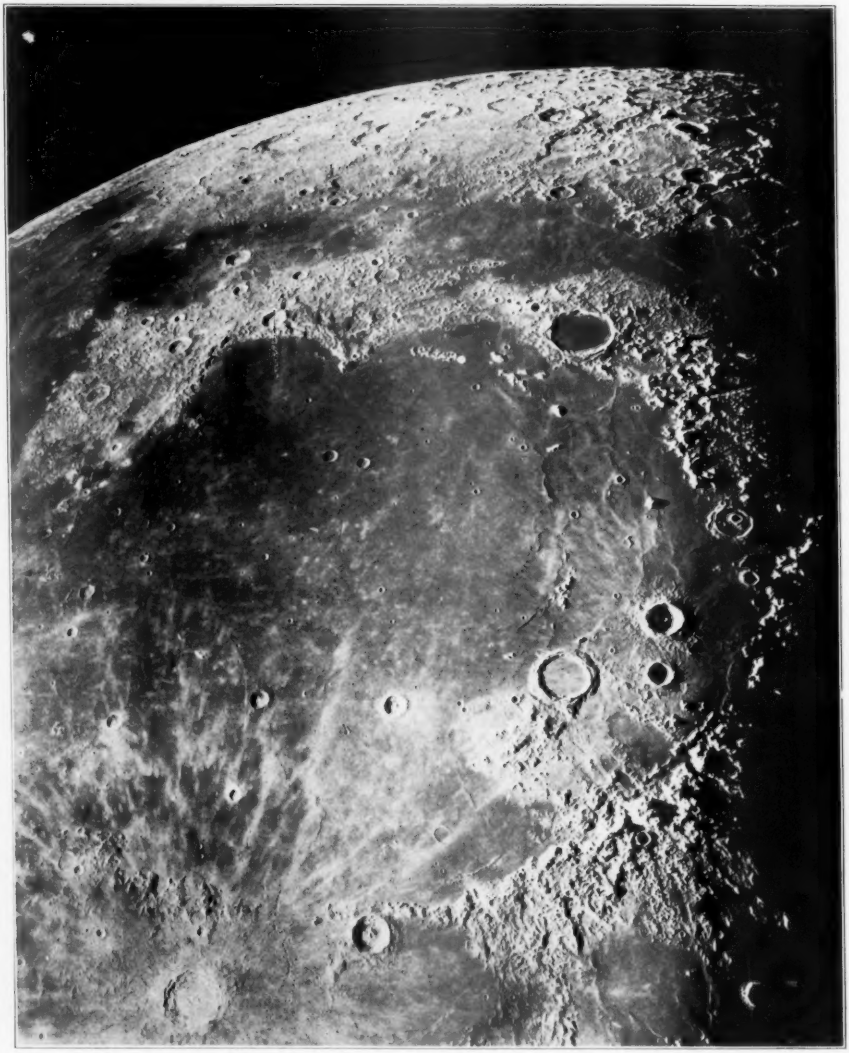
here be gone into farther, but it will be recognized that the above ideas are quite incompatible with one prominent theory that has received extensive recognition in which it is deduced that the moon was formerly a part of the mass of the earth, that it was thrown off or torn off, and then assumed a spherical form and an orbit of revolution about its parent planet.

It must be conceded that all this is much like attempting to arrive at a conception of an immensely large magnitude by using an extremely minute unit of measurement. Nothing has ever occurred under human observation in the way of an actual event on the scale of a mass of matter say at least 20 or 30 miles in diameter colliding head on with another body of the size of the moon at a high relative velocity. Our conjectures as to results may be made as logical as our limited knowledge, facilities for observation, and powers of reasoning permit; but they remain conjectures, with a considerable margin or probable error and uncertainty.

The foregoing leads to some rather interesting speculations in a still wider field. While the surface features of the earth present in general a radically different pattern from those of the moon, there are several points of resemblance, and considerations similar to the above may throw light on some long standing conundrums of terrestrial physiography. This refers to certain curvilinear forms on the earth that have been the subject of much theorizing and guessing. Among these are conspicuously the line-up of the islands forming the northern and eastern boundaries of the Carribean sea, and the similar curved arrangement of the long peninsula and the Aleutian islands extending south-westward from Alaska and inclosing the Behring sea. Somewhat less obvious, but also suggestive, are the long curved lines of the Japanese and other islands off the east coast of Asia and the much longer succession of islands beginning near New Guinea, north of Australia, and extending westward through Timor, Java and Summatra, and then northward through several smaller island groups. There are also various lines and curves of volcanic islands and shoal spots on a much smaller scale, especially in the western Pacific area. The significance of these is still more apparent when seen on a hydrographic chart that shows also the great submerged shoals and deeps of the ocean. There are several instances of similar curved and linear patterns in the great land mountain chains of the earth and in some of the coast lines.

Note may here be made of the sheets of ancient lava that overspread large areas in various parts of the world, notably in our own country in the states of Washington, Oregon, and Idaho. Here the mantle of solidified lava is apparently composed of several superposed layers and it exhibits a number of long rifts or "coulees" some of which are now occupied by large water courses, as in the case of the Snake and Columbia rivers. Other significent features are the Yosemite and Hetch

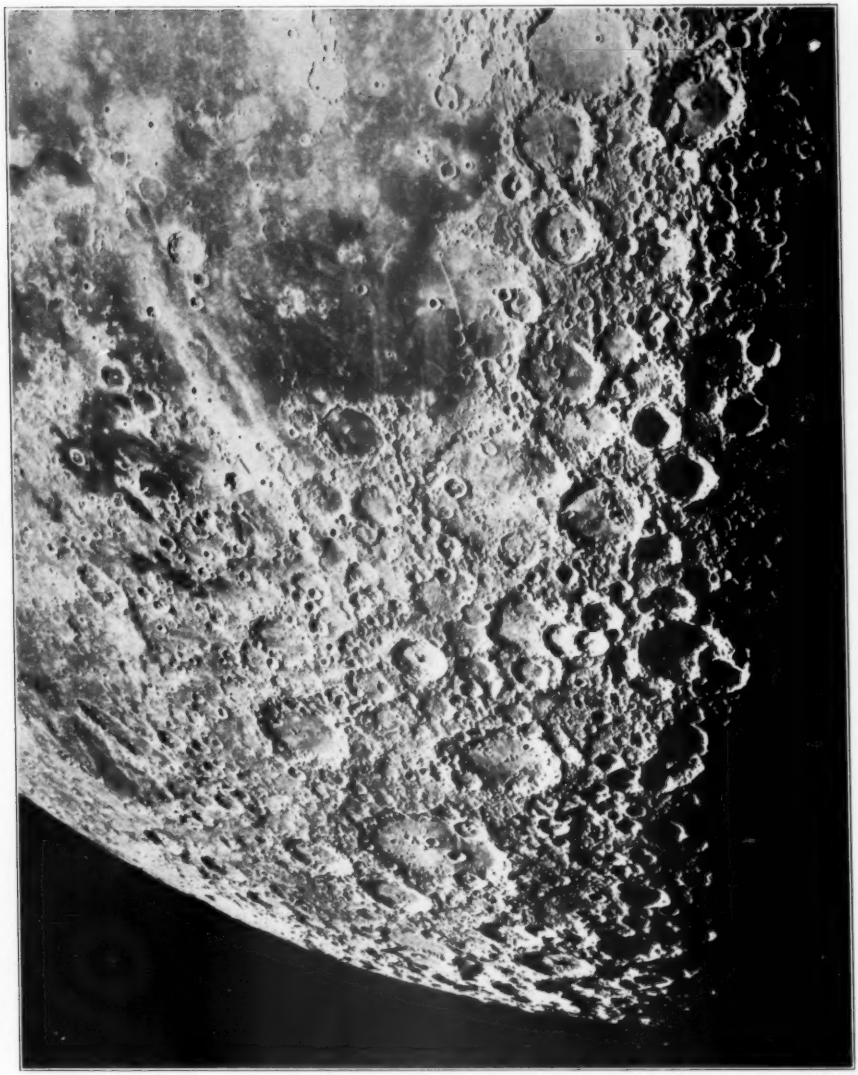
PLATE II.



NORTHERN PORTION OF THE MOON AT LAST QUARTER,

made with the Hooker 100-inch Reflector, Mount Wilson Observatory, on September 15, 1919.

PLATE III.



SOUTHERN PORTION OF THE MOON AT LAST QUARTER,

made with the Hooker 100-inch Reflector, Mount Wilson Observatory, on September 15, 1919.

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Hetchy valleys of California, the Royal Gorge of Colorado, the great submerged canyons in the sea bottom off the coast of California, off the mouth of the Hudson, and off the mouth of the African Kongo; the system of "wadys" or rifts in northeastern Africa and Asia Minor, the network of fjords in Norway, and the smaller "canals" or cracks in the earth's crust along the coast in southern Alaska and in southern Chile and Patagonia. There has not yet been any very satisfactory explanation of these numerous evidences of what were apparently stretching or expanding influences affecting the earth's crust, and the same may be said of the catastrophic occurrences or "convulsions of nature," whatever they may have been, that have long been regarded as concerned at least in part in the upheaval of great mountain masses, in faults, overthrusts, and other displacements in the earth's crust. All these are described and discussed in great detail by Suess in his voluminous and masterly work on the "Face of the Earth," but his speculations as to fundamental causes are not very definite or conclusive.

Finally a brief reference to the much discussed problem of the surface variations on Mars is appropriate. The similarity between the so-called "canals" on Mars and the lines on the moon's surface has heretofore been noted, but in addition there will be found running through the bewildering maze of accumulated drawings and sketches of the surface of Mars that have been made by numerous observers

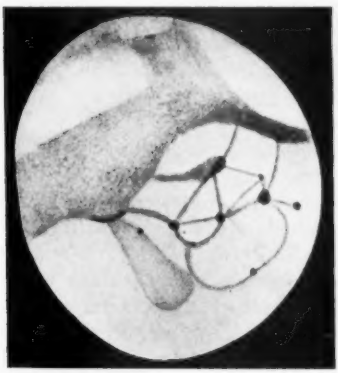

FIG. 1.

FIG. 2.

HOW MARS LOOKS WHEN SEEN UNDER THE BEST POSSIBLE CONDITIONS.

From drawings made by Professor W. H. Pickering at Lowell Observatory, Flagstaff, Arizona, during the favorable opposition of the planet in 1894. Scale 1 to 100,000,000 or 1,600 miles to 1 inch. Fig. 1 shows canals and lakes about Solis Lacus; Fig 2, canals crossing seas south of Syrtis Major. Flattening of the terminator or dark edge of the planet, over seas, is also shown in Fig. 1. Both figures show light shading in lower part of disc, which precedes formation of canals.

many forms that indicate patches with curved boundaries, cusps or peninsulas between areas with similar boundaries, curved and tapering hooks, and even round spots or "oases" that suggest the possibility of immense crater areas, as well as other features similar to those of the moon that have been discussed.

With reference to the well-known network of long straight intersecting lines or streaks on the surface of Mars—the famous "canal" system—it can be said with confidence that, from the point of view of the engineer having to do practically with artificial works for conveying and distributing water on the surface of the earth under the influence of terrestrial gravity, the lines that are found on the numerous maps of Mars cannot possibly be related to works of similar character. It would be as logical to expect to find throughout the United States a system of canals for navigation and irrigation, with bordering areas or belts under cultivation, that followed the general layout presented by the parallels of latitude and meridians of longitude shown on an ordinary map of the country.

The suggestion is obvious that there is a strong probability of some direct and fundamental relationship among the forces and actions that produced these various forms and markings on the surfaces of the three bodies referred to, and it seems not unreasonable to hope that a more intensive study of our nearest celestial neighbor may contribute very materially to a better understanding of a number of outstanding cosmical problems.

While no theory is here proposed concerning the previous history of the matter that now constitutes the moon, it will be understood that the ideas outlined point to some interpretation resembling G. K. Gilbert's theory of a former Saturn-like ring of meteors for the earth, and the planetesimal hypothesis of T. C. Chamberlin.

In respect to the earth at least, the suggestion is deduced that volcanism may be more in the nature of a local phenomenon than has heretofore been recognized, and notably significant are numerous crater-like pits or walled depressions and other circular forms, up to fifteen miles in diameter, that are found in various localities on the earth's surface and whose origin is still more or less an open question. Many volcanic regions may be the loci of something like deep-seated crustal weakness, generally overgrown and greatly obscured by subsequent geological history, like old wounds or scars never entirely healed. Some of these still display manifestations of residual internal heat that has not been fully dissipated, possibly augmented or sustained by the localization of tidal movements in the crust, but which originated primarily in a tremendous local cataclysm of long ago.

Perhaps we have something here that will fit in as a very minor incident of a great universal cyclic process of assembly and agglomeration, followed by mutually destructive encounter, as when two bodies of nearly equal mass may come into contact, with dispersion again

into a widely diffused state;—these respective classes of phenomena following each other alternately during endless time and throughout unlimited space.

542 Rush Street, Chicago.
August 8, 1922.

PHOTOGRAPHIC ADJUSTMENT OF THE EQUATORIAL.

By HEBER D. CURTIS.

Many large modern equatorials are unprovided with those expensive and unnecessary luxuries—finely divided position circles. The following method of adjusting the position of the polar axis requires no fine circles, is easy of application, and may be employed with any telescope which can be pointed at the pole and which is provided with an attachment for carrying a photographic plate.

It is presupposed that the polar axis points somewhere near the pole, say within one-half of a degree. This result can easily be secured by any of the numerous mechanical or visual methods for approximate adjustment. Let it be required to set the polar axis so as to point as closely as possible to the celestial pole, as affected by refraction.

The method consists essentially in first determining the position in the sky of the axis of rotation of the polar axis, and then trailing the stars near the pole to determine the position of the true refracted pole.

Clamp the telescope tightly at 90° declination as indicated by the coarse circle, which should be in approximate adjustment. Start with the telescope in some definite position as, for instance, at zero hour angle west of the pier. Take in rapid succession a series of short exposures of ten seconds to two minutes each, depending upon the rapidity of the instrument, and at hour angles of roughly 0, 1, 2, 3, 4, etc., hours; the exact intervals of hour angle are unimportant. Be careful not to change the setting of the telescope in declination in moving from one hour angle to the next; it is best to do this by means of a cord tied to the end of the declination axis. Be careful also in clamping and unclamping the telescope in right ascension for the short exposures; with rapid instruments it will generally be unnecessary to clamp, getting instead of round images short trails of a minute or so at each hour angle. By this process the stars about the pole imprint upon the plate a series of arcs marked by dots or very short trails, and the center of these arcs marks the place in the sky to which the axis of rotation of the instrument is pointing.

Now bring the telescope back to its initial position in the meridian at the west of the pier, or so that one edge of the plate may be horizontal. Stop the clock, open the plate shutter, and allow the stars

to trail for several hours.* The center of these trail arcs will be the position of the refracted celestial pole. Mark the plate carefully on taking from the holder, so that there may be no doubt as to its orientation during the taking of the polar trails.

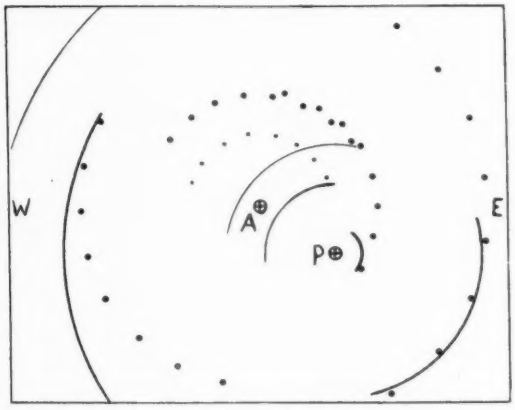

FIGURE 1.

On developing, you will have a plate somewhat like the diagram of Figure 1, with everything that is needed for adjusting the position of the polar axis on a single plate. (The diagram does *not* show the actual configuration of the circumpolar stars.) In fact, unless the telescope tube and mounting are adequately rigid, you are quite likely to find also some much less welcome truths as to the amount of flexure in the instrument. Locate the centers of the two systems of arcs by geometry, or draw a considerable number of concentric circles of different radii on a sheet of paper, and shift the plate over this sheet until you can make the star arcs coincide with some one of the circles and thus locate the centers. It would be quite possible, though an unnecessary refinement, to measure the arc points on a measuring engine, and solve by least squares for the coordinates of the centers.

Let us suppose that the diagram of Figure 1 was taken with an instrument of 200 inches focal length and that, as shown, the true refracted pole was found to be 0.75 inch to the east and 0.50 inch above the pole of the instrument. Getting the tangents of the angular errors by dividing these quantities by the focal length, the error in azimuth would be 12′ 53″, and that in altitude 8′ 36″. Calculate the amount by which the altitude adjusting screws must be turned to in-

*Most telescopes will show trails of the brighter of the slowly moving circumpolar stars. If not, run the clock for a minute or two at intervals of an hour, stopping it in the intervals between. Make the first two exposures only fifteen minutes apart, to differentiate this second set of dots from the first.

crease the altitude of the polar axis by 8′ 36″ and make the correction. Or use the equation,—

$$\text{Number of turns of screw} = \frac{E\ d\ s}{\text{focal length}},$$

where s represents the number of threads per inch of the adjusting screws, d the base line or leverage of such adjustment, and E the error of position as measured in inches on the plate.

Do the same for the azimuth correction; if the screws for this adjustment, as is frequently the case, act in a horizontal plane, the amount of rotation found from the plate must be multiplied by the secant of the latitude. A repetition of the process will generally give a very accurate adjustment of the polar axis. By this method the axis of rotation of the Crossley Reflector at Lick Observatory was brought within about five seconds of arc of the true refracted pole, an accuracy of adjustment that is needed only when exposures of some length are to be made in high declinations.

With an instrument which can not reach the pole, or whose tube is rigidly fastened to the polar axis without movement in declination (as is frequently the case with eclipse instruments), it would be possible to clamp an auxiliary telescope to the axis so as to point at the pole, but the following modification will generally be more convenient.

For the altitude adjustment of the polar axis choose a star or field well away from the meridian, five or six hours if possible; for the azimuth adjustment take one near the meridian. With the clock running, expose for an hour or more; then stop the clock and allow the star to trail. If the star is too faint to trail, run the clock for a minute, stop for five minutes or so, run again for a minute, etc., so as to secure three or four dots instead of a trail. The image of the star formed by the long exposure will be a short trail, part of which (the component in right ascension) is due mainly to the erroneous rate of the driving clock; the other component (that in declination) is due mainly to the improper adjustment of the polar axis in altitude or azimuth. Measure the length of this component, that is, at right angles to the trail or to the line of the "trail dots" produced, and convert into angular measure. The error in the position of the polar axis will be given by—

$$\text{Error (minutes of arc)} = \text{Trail in } \delta \text{ (minutes of arc)} \times \text{cosecant of the exposure time,}$$

or, if the exposure was just one hour,—

$$\text{Error } (') = \text{Trail in } \delta\ (') \times 3.86.$$

For a moderately bright star, the trail of the long exposure is apt to be so broad that it is difficult to measure the declination component of the trail with accuracy. In such cases it is preferable to replace the hour exposure by two exposures of, say, thirty seconds to a minute

each, separated from each other by an interval of one hour, during which the clock was kept running and the telescope clamped.

The formulae given above are not rigorous, but are sufficiently close as approximations under the conditions of the test, if exposures are begun near to the six hour circle and to the meridian respectively. As in the other method, mark the plate carefully before removing from the holder. Both tests may be made on the same plate, by breaking one trail or varying the spacing of the "trail dots" so as to differentiate the altitude and azimuth tests.

Differential refraction has practically no effect on the azimuth adjustment in this method; in the altitude test it tends (at latitude 40°) to place the polar axis nearly 2′ above the refracted pole if a star of 30° declination is employed, but will place the pole of the instrument very close to the refracted pole if a star of from 50° to 70° declination is used. For the greatest accuracy in the altitude adjustment it will be necessary to compute the refractions in declination at the beginning and end of the exposure and allow for same.

For altitude;—star near six hour circle to the east; exposure trails to the south,—then the north end of the polar axis is too low.

For azimuth;—star near meridian; exposure trails to the south—then the north end of the polar axis is too far to the east.

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TWENTY-EIGHTH MEETING OF THE AMERICAN ASTRONOMICAL SOCIETY.

(Continued from page 628, Vol. XXX.)

ABSTRACTS OF PAPERS

INTERFEROMETER MEASURES OF STAR DIAMETERS.

By A. A. Michelson and F. G. Pease.

During the past year measures have been made with the 20-foot interferometer with two ideas in mind, first to record for a star the highest visibility at 19-feet and second to calibrate the beam by making measures with all sorts of mirror separations and during all grades of seeing, using for the purpose early type stars having small hypothetical angular diameters. The measures for α Orionis and α Scorpii remain as before. The readings of α Orionis are slightly smaller than before but this is to be attributed to poorer seeing. The visibility-curves of α Tauri, α Bootis and β Pegasi are very much the same and intercept the axis at about 22 feet. The seeing factor, at present uncertain, will probably increase this value to nearer 25 feet. γ Andromedae shows indications that the fringes will vanish between 30 and 40 feet and

α Arietis between 40 and 50 feet. The following stars have shown high visibilities at the end of the beam: α Canis Majoris, α Canis Minoris, α Cygni, α Geminorum, α Ophiuchi, α Andromedae, α Pegasi, α Cassiopeiae, β Leonis, γ Orionis, γ Cassiopeiae and ϵ Cygni. Finally α Aquilae, α Leonis and α Virginis have at times shown fringes of full visibility and therefore an estimation of their diameter cannot be made with this beam. For months the readings of α Lyrae fell below those of α Aquilae and it was therefore thought to be much larger in diameter. It was later found however that the average seeing was better on α Aquilae, and on several occasions high visibility was obtained for α Lyrae. A number of stars fainter than magnitude 2.8 were observed but measurements could not be made with any certainty.

For calibrating the beam mention was made in last year's report of the Mt. Wilson Observatory of an auxiliary interferometer having one variable aperture which was to serve two purposes, one the matching of the interferometer fringes for visibility and the other the measurement of the seeing by the disappearance of the fringes. It was found easy to match the interferometer fringes with the zero fringes during good seeing, but during bad seeing the two sets varied independently of one another, changing as much as 50 per cent in a few seconds. After much practice however the visibility scale is learned and on nights of unsteady seeing, the eye method of estimating visibilities is used. It has also been decided to try out an artificial star image and see if it can be applied in this case. During good seeing the readings for the vanishing of the zero fringes remain quite constant through the night and the measure of the seeing thus obtained is quite reliable. On nights of poor seeing, however, readings of the visibilities of the 20-foot interferometer fringes and the vanishing of the zero fringes are not directly applicable, and an endeavor is made to judge the seeing from the appearance of the 20-foot images themselves with regard to sharpness, diffraction rings, etc.

The scale of interferometer seeing does not follow that of ordinary seeing. Ordinary seeing is a question of amplitude. Interferometer seeing is only a question of phase. Hard sharp images buffeted wildly about will give excellent readings with the interferometer whenever the two pencils overlap but will give large images on a photographic plate. Large diffuse images, however, yield poor results in both cases An important contribution on the question of ordinary seeing has been answered by the 20-foot interferometer. There is no practical change in the general appearance of the diffraction images given by pencils from 8 feet to 20 feet apart. The size of the central disks is about 20 per cent greater than the disks from pencils 45 inches apart and they are softer in appearance, but part of this is due to the two additional reflections from mirrors not accurately figured. The excursion of the image from the mean center over this range of 8 to 20 feet is practically the same on a night of uniform seeing.

TRIGONOMETRIC PARALLAXES OF CEPHEIDS AND EARLY TYPE STARS DETERMINED BY PHOTOGRAPHY AT THE LEANDER McCORMICK OBSERVATORY.

By S. A. Mitchell.

Up to September 1922 the trigonometric parallaxes of more than 500 stars had been determined by photography with the 26-inch visual refractor of the McCormick Observatory. By a method described at the 1920 meeting of the American Astronomical Society a successful process has been obtained for reducing the images of the brightest stars on the photograph to equality in size with the average comparison star of tenth visual magnitude. The parallaxes of 53 stars brighter than magnitude 3.0 have thus been determined. Among these are Sirius with a relative parallax of $+0''.354 \pm 0''.008$ and α Orionis with a value $+0''.013 \pm 0''.006$. Twenty-six stars of B-type have been completed, and 50 stars of type A, and also 22 stars listed by Adams as Cepheids or pseudo-Cepheids.

Sixteen McCormick stars having types from B0 to B5 have an average absolute magnitude approximately —2.0, and 10 stars of types B8 and B9 have an absolute magnitude 0.0. Thirty-six stars of types A0 to A3 have an average absolute magnitude of +0.6, while 13 stars of types A5 to A8 average +2.2 in absolute magnitude. These early type stars thus show a steady decrease in absolute magnitude with progression in type. The parallaxes of the stars of A-type were compared with the spectroscopic parallaxes of the Mount Wilson observers soon to be published, and on the average there was a very close agreement.

The following parallaxes have been measured for the Cepheids and stars which closely resemble the Cepheids. The parallaxes are the values relative to the comparison stars of approximately tenth visual magnitude, and to derive the absolute parallax 0".005 should be added to the relative parallaxes. The stars are arranged in order of right ascension.

α Persei	$+0''.013 \pm .010$	S Sagittae	$0''.000 \pm .004$
58 Persei	$+ .023 \pm .008$	α' Capricorni	$- .017 \pm .009$
α Leporis	$+ .009 \pm .008$	γ Cygni	$- .003 \pm .013$
T Monocerotis	$- .012 \pm .008$	ρ Capricorni	$+ .019 \pm .013$
RT Aurigae	$- .002 \pm .008$	41 Cygni	$- .023 \pm .006$
ζ Geminorum	$+ .006 \pm .010$	T Vulpeculae	$+ .015 \pm .007$
ρ Puppis	$+ .026 \pm .008$	β Aquarii	$- .001 \pm .012$
β Draconis	$- .015 \pm .007$	γ Capricorni	$+ .013 \pm .009$
π Sagittae	$+ .012 \pm .012$	α Aquarii	$+ .005 \pm .010$
U Vulpeculae	$- .004 \pm .009$	δ Cephei	$+ .002 \pm .008$
η Aquilae	$- .001 \pm .009$	ρ Cassiopeiae	$+ .041 \pm .010$

A comparison was made with the spectroscopic values of Adams and Joy after applying the correction of 0".005 to reduce the above to absolute parallaxes. For the 22 stars, the average difference between McCormick and spectroscopic is 0".011, while the McCormick results are on the average 0".0012 larger than the spectroscopic parallaxes.

This difference, small in size, is entirely accounted for by the last star of the above list where the difference is much greater than the average, so that it is safe to assume that the spectroscopic parallaxes of the Cepheids seem to fit very closely the scale of the trigonometric parallaxes of the McCormick Observatory.

ON THE DAILY VARIATION IN CLOCK CORRECTIONS.

By H. R. Morgan.

The results presented in this paper were obtained from a discussion of 3600 observations of clock stars, on 463 nights, from 1913 to 1921, made with the 9-inch transit circle of the U. S. Naval Observatory, and the details of the discussion will appear in the *Astronomical Journal*.

It is found that there is practically no daily variation in the clock corrections, and that the clocks have the same rate day and night. This result agrees with that found from the discussion of the work on this instrument from 1903 to 1911, as given in a paper read at the Swarthmore meeting, and published in the *Astronomical Journal* No. 795.

PHOTOMETRIC RESULTS IN CERTAIN KAPTEYN AREAS.

By J. A. Parkhurst.

The Yerkes Observatory assumed the investigation of the 24 Kapteyn Areas one hour apart around the sky at declination +45°. The photometric work now completed consists in the determination of the photographic, photo-visual magnitudes, and color-indices of all the stars found on the plates taken for parallax and proper-motion by Mr. Lee with the 40-inch refractor. These photometric results were found from plates taken by the writer with the 6-inch Zeiss UV camera, the 2-foot reflector and the 40-inch refractor. Spectra taken with an objective prism on the UV camera were used in the selection of white stars for standards near each area, and to obtain photographic magnitudes from the visual catalogs.

The magnitudes were based on the International System, and it was found that more consistent results were obtained by the use of the magnitudes of the white standards near each area taken from the Potsdam and Harvard catalogues, than by connecting with the more distant North Polar Sequence. The photometric scale was found independently on each plate, by the difference between the central image and first order spectra, from an objective grating.

In discussing the results it appeared that the stars in the areas near the galaxy had a larger mean color-index than those in the areas remote from the galaxy. As the galactic areas contained a greater number of faint stars, the relation between the color-indices of stars of different magnitudes was discussed, when it appeared that the mean color-index was independent of the magnitude.

THE TOTAL RADIATION OF VARIABLE STARS OBSERVED WITH THE VACUUM THERMOCOUPLE AT MOUNT WILSON.

By Edison Pettit and Seth B. Nicholson.

The vacuum thermocouple is mounted in the double-slide plate-carrier at the Newtonian focus of the 100-inch telescope and is connected with the d'Arsonval galvanometer in the basement by a cable 135 feet long, which also provides telephonic communication between the telescope and galvanometer. The galvanometer deflections are registered photographically and afterward measured on a suitable comparator. In practice the two junctions of the thermocouple are set alternately on the star image at intervals of 30 seconds, which causes the galvanometer to produce a broken line on the plate, the displacements in which are the deflections. The galvanometer is so steady that a deflection of 0.14 mm on VX Andromedae was measured with a probable error of ± 0.008 mm with six deflections, and a similar deflection of 102.75 ± 0.015 mm was measured for Arcturus.

We have used the term "heat index" to mean the radiometric minus the visual magnitude, the former being defined as the magnitude of an A0 star which would have the same total radiation as the star in question. This is effectually the ratio between the total and visual radiation and is a means of determining the relative emission temperatures of the stars. The water cell absorption is the ratio between the total radiation and the radiation transmitted by a water cell 1 cm thick, expressed in magnitudes, which indicates the distribution of the energy in the spectrum beyond $1.13\,\mu$.

Table I.

Star	Type	Heat Index	Water Cell Absorption	Visual Magnitude	Visual Range	Temperature, Centigrade
RT Cygni	Md2	1.5	0.9	6.8	7-12	3960°
χ Cygni	Md6	8.0	1.7	9.1	4-13	1690
R Cancri	Md8	6.2	1.6	8.3	7-12	1910
X Ophiuchi	Md8	5.6	1.6	7.3	7-9	2040
"		6.1	1.9	8.0		1940
R Leonis	Md10	8.3	2.2	9.4	6-10	1650
R Hydrae	Md10	8.0	1.9	9.0	5-10	1710
R Aquilae	Md10	6.8	1.9	9.8	6-12	1810
"		4.4	1.6	6.5		2260
o Ceti	Md10	7.6	(1.3)	9.0	2-9	1720
		6.6	1.6	6.6		1850

Table I gives the heat index and water cell absorption for eight variable stars of the class Md which we have observed at different phases. RT Cygni, R Cancri, X Ophiuchi and *o* Ceti have been observed near the maximum phase as will be noted by comparing the columns labelled visual magnitude and visual range. Relatively low heat index and water cell absorption will be noted. R Hydrae, R Aquilae, and *o* Ceti have been observed near minimum phase. Larger heat indices and water cell absorption will be noted for these. The temperatures in the last column were obtained from the heat index,

assuming a temperature of 5000° C for α Arietis, a K0 star of heat index 0.9 magnitude. Assuming further that the stars radiate as black bodies, and that the visual light is proportional to the radiation at wave-length 0.54 μ an approximate value of the temperature is here obtained. Near minimum phase such stars as R Leonis, R Hydrae, and o Ceti have a radiation temperature of about 1700° C, while at maximum phase the temperature is about 1900 to 2000° C as in the cases of R Cancri, X Ophiuchi, and o Ceti, but may be as great as 3960° C, as in the case of RT Cygni. In the case of R Aquilae a change of temperature of 450° C is accompanied by a light variation of 3.3 magnitudes, and a change in temperature of 130° C in o Ceti is accompanied by a light variation of 2.4 magnitudes.

A PENDULUM METHOD OF RECORDING RADIO TIME SIGNALS.

By Edward C. Phillips.

If the primary or secondary circuit of a crystal radio receiving set is broken and a mercury contact pendulum (or a make-circuit chronometer) is placed across the gap formed in the radio circuit the radio signals will be audible only when the pendulum or the chronometer beats are in coincidence with the radio time signals; if the period of the pendulum or of the chronometer is made slightly longer than a mean time second, say 1.02 seconds, the moments of contact of the pendulum or chronometer will creep up on the time signals and when the moment of contact gets into coincidence with the beginning of the time signals these become audible; if the pendulum or chronometer circuit is then thrown into the chronograph circuit, instants of time which lag by a known amount behind the corresponding time signals will be recorded on the chronograph along with the record of the observatory clock which is made to operate the chronograph throughout the period of observation. A series of experiments with an instrument constructed on the above principles has given very consistent results; the absolute error of the results obtained in a single series of observations during the five minutes in which radio signals are sent out each day from the Arlington station, is thought to be less than one hundredth of a second; the probable error of such a series calculated in the ordinary way is from 3 to 4 thousandths of a second.

THE SPECTRA OF THREE O-TYPE STARS.

By H. H. Plaskett.

A detailed study of the spectra of 10 Lacertae (Oe5), 9 Sagittae (Oe5) and B. D. 35°3930 N (Oe) has led to the discussion of a number of interesting problems. On the one hand these stellar spectroscopic data have been applied in order to obtain a confirmation of well-

known physical theories on atomic structure. The evidence is given in detail for the previously announced discovery of Bohr's predicted enhanced helium components to the Balmer lines (H. H. P., *Nature*, **108**, 209, 1921). From the wave-lengths of all the enhanced helium lines in these O-type stars the value of the Rydberg constant for helium is computed, using Sommerfeld's extension of Bohr's theory. From this value of N_2, "stellar spectroscopic" values of a number of important universal constants—the electron mass, its radius, the value of Planck's constant h, the radiation constant c_2, etc.—are computed and compared with the numerical values derived from other methods.

On the other hand recent physical theories, developed chiefly by Saha, are applied to the observed spectra in order to learn some of the physical conditions in the chromospheres of these three O-type stars. Saha's theory is first modified to allow for the relative abundance of elements—a modification which readily accounts for the apparently anomalous behaviour of barium and sodium in the sun, discussed by Russell,—and a check hypothesis of ionization by electron collisions is formulated. From the use of these two methods, assuming the relative abundance of magnesium to be the same in the stars as on the earth, the temperature of 9 Sagittae is deduced from the disappearance of Mg 4481 to be 18,500° K. The temperatures of 10 Lacertae and B. D. 35°3930 N from the intensities of their lines are placed with some uncertainty at 15,000° K and 22,000° K respectively. From these temperatures it is shown that while the relative abundance of hydrogen is of the same order in O-type stars and on the earth, helium is probably 10^6 times more abundant in O-type stars. These facts find a simple explanation when probable nuclear disintegrations in lower layers of the star are considered. Finally in the light of the preceding discussions a modification of the present Harvard classification of absorption-line O-type stars is considered, and a table is given of the line intensities, the present and suggested types of some 33 absorption-line Class O stars.

This paper is in the press and will shortly appear in the *Publications of the Dominion Astrophysical Observatory*.

THE ULTRA-VIOLET SPECTROGRAPH OF THE 72-IN. TELESCOPE.

By J. S. Plaskett.

The ultra-violet spectrograph for the 72-inch telescope was obtained from Hilger, London. Its optical train consists of two 60° prisms of ultra-violet crown glass and single element collimator and camera lenses each of 40 mm aperture and 200 mm focal length. As there is no correction for achromatism the plate is inclined about 50° from the normal to the optical axis. The resulting linear dispersion is 105 A to the millimetre at Hγ, about 50 at λ3600 and 37 at λ3300.

The defining power is excellent over the whole spectrum from λ3200 to λ7000, but the field is strongly curved concave to the lens with a radius of curvature perpendicular to the plate of about 15 cm. The result of this curvature of field is that not more than about 400 to 500 A can be in sufficiently good focus at one time on a flat plate.

Glass plates can not be bent to this radius but special plate holders with suitably curved surfaces to hold film closely to the proper curvature have been made with the result that the whole spectrum between 3200 and 7000 can be obtained sharply defined on one film. Camera and prisms are mounted on a minimum deviation link work so that any region of spectrum can be made central.

The mounting is well designed and rigid and the spectrograph is readily attached to the focussing ring at the principal focus of the 72-inch mirror. The spectrograph proper is surrounded by a felt lined wooden case with heating wires controlled by a Callendar Recorder, so that the temperature can be maintained constant. Preliminary test spectra of various early-type stars show excellent definition and good extension in the ultra-violet, and there seems no doubt that the instrument will work efficiently and give valuable results.

SOME FINE OCCULTATIONS COMING.

By William F. Rigge.

As more than ten years have passed since the last favorable occultation of a bright star was visible in the United States, amateurs and professionals alike will be interested in the gentle shower that will soon be upon us. Before the end of 1923 Aldebaran will be occulted five times, and Venus and Saturn once. The maps for all these are ready and will be published in Popular Astronomy in due time, the first occultation on the list being that of Aldebaran on September 13.

PLANETARY PHOTOGRAPHY.

By Frank E. Ross.

A study was made by means of laboratory experiments of the limitations of planetary photography depending on the photographic plate. Assuming a telescope of 270-foot focus and an object at the opposition distance of Mars, it was found that a fine-grain photographic plate is capable of showing linear objects 1.5 miles wide. It was found that the true size of detail could not be calculated from the size of the photographic image. These results hold only in the case of great contrast between detail and background, the size of minimum detail increasing with a lowering of contrast. Thus for a relative contrast of 23 per cent an object not less than 7 miles wide could be photographed on Mars under the above conditions. It was found in this case that the true size of detail was correctly rendered by the photographic plate.

ACCURACY OF PHOTOGRAPHIC POSITION REGISTRATION.

By Frank E. Ross.

An attempt was made, from a study of the accidental and systematic errors to which position measures are subject, to gain a clearer insight into the mechanism of the photographic process. Perrine's result, that distances on the plate were affected by the thickness of the emulsion, was not sustained. It was found that there was no systematic difference between weak and strong images, although it is evident that such would not be the case with images formed by an imperfect optical system. The probable error of a single distance ranged from 0.4 μ to 0.8 μ, depending on the plate. These very small values show that the so-called plate error is not to be feared, at least for standard emulsions carefully handled. In addition it was found that the probable error for weak images was little if any greater than for strong images, which, combined with the further fact found that images very irregular in outline did not apparently lead to irregularities in distance, leads one to doubt the irregularity-of-outline explanation of image displacements. A theory of gelatine displacements overcomes these difficulties, as well as explaining the very large displacements occasionally found by investigators.

It was found that when a plate dried images near the edge moved outward by a distance of the order of 50 μ. At one centimeter from the edge the movement ceased. The explanation of this phenomenon is to be found in a general property of colloid solutions.

The effect of intensifying photographic star images was investigated. No beneficial effect was observed, except for a slight reduction of the accidental error of measurement. In addition no systematic differences were disclosed.

IONIZATION AND PRESSURE IN THE REVERSING LAYERS OF THE STARS.

By Henry Norris Russell.

1. Atkinson has recently discussed the dissociation of TiO_2 vapor in stellar atmospheres, and concluded that the pressures are exceedingly low. It is probable that the oxygen resulting from this dissociation is not in the molecular state (as he assumes) but in the atomic condition. This modifies the equations, and leads to a partial pressure of the order of 10^{-4} atmospheres for titanium and oxygen together, and probably 10^{-2} to 10^{-3} atmospheres for the total pressure.

2. Following a remark by Debye (quoted by Atkinson) to the effect that in a gas when the total mass of ions present was 10^{-6} gm/cm^3, the Stark effect due to the molecular fields would greatly broaden all the lines in the spectrum, it may be concluded that in the reversing layers of all the hotter stars (Class F and earlier), where most of the metals

are ionized, the density of the gas does not exceed about 10^{-7} gm/cm^3, nor the pressure 5×10^{-3} atmospheres. If the abundance of the easily ionized alkalies and alkaline earths is as great in the stars as on the earth, the pressure can not exceed 0.1 atmospheres, even in Class K, if the lines are to be sharp.

It appears, therefore, in general, that the pressures in the reversing layers of the stars must be small (probably only a few millimeters of mercury, on the ordinary scale). The redder dwarfs may be an exception to this.

3. The intensity of the arc lines of various elements, as the ionization increases, will depend upon the number of neutral atoms remaining, and hence both on the relative abundance of the elements and the degree to which their atoms are ionized.

The arc lines of an abundant element may persist at higher temperatures than those of a less abundant element of higher ionization potential, and its enhanced lines appear at lower temperatures than those of a rare element of lower ionization potential.

The fact that the fundamental arc line of calcium, λ 4227, lasts farther up the spectral sequence than λ 4030 of manganese may be thus explained. The extraordinary persistence of the Balmer series of hydrogen—to which Saha calls attention as an anomaly—may be directly related to the fact that in the outer ten miles of the Earth's crust, there are more atoms of hydrogen than of all the metals put together.

4. In stars of Class O, where the Balmer and Pickering series are simultaneously present, and comparable in intensity, the pressure may be estimated as of the order of 0.01 atmospheres, and the temperature of the order of 15,000°.

5. In explanation of the habitual appearance in stars of Class B with bright lines, of bright Hα (and perhaps Hβ, Hγ) with absorption lines of hydrogen in the ultra-violet it is suggested that the energy absorbed by the hydrogen atoms from the strong ultra-violet radiation of the photosphere, (which raises the electron from the quantum state 2 to states 7, 8, and higher,) may be radiated in two steps, the first involving a drop from this higher state to state 3 or 4, and emission of lines of one or other of the series in the infra-red, and the second a drop from state 3 or 4 back to state 2 and emission of Hα or Hβ. In this way enough energy may be fed into the changes resulting in emission of the latter lines to make them brighter than the neighboring radiation of the photosphere, which, in these very hot stars, carries much less energy than the ultra-violet. On this hypothesis the Paschen series of hydrogen in the infra-red should be very bright in these stars. It is unfortunately impossible to test this by observation at present.

It is also suggested, with much more reserve, that the type of hydrogen emission in the long-period variables, where the lines in the violet are brighter than Hα, may be brought about by a reversal of the process sketched above—absorption of energy in the infra-red—in two

successive steps, and discharge in a single step, giving emission of short wave-lengths in a region where these cool stars radiate little energy.

FURTHER OBSERVATIONS ON THE SPECTRA OF VENUS.

By Charles E. St. John and Seth B. Nicholson.

The importance of planetary spectra for standardizing stellar spectrographs and the bearing of Evershed's early observations of the spectra of Venus upon the explanation of the displacement of solar lines have made advisable further investigation of the anomalies found in the spectra of Venus. Evershed's measures showed that on his spectrograms of Venus the positive sun-arc displacement of the Fraunhofer lines decreased with increase of the angle Venus-Sun-Earth until for the solar hemisphere opposite the earth the displacement became negative in sign. He suggested at that time a repulsion of the solar vapors by earth-action as the explanation of his observations and also of the general displacement of solar lines to the red.

From 56 spectrograms of Venus taken in 1919-1920 we found that the observed differences between the wave-lengths in skylight and in sunlight reflected for Venus at various phases were best represented by an empirical formula derived from the consideration that dispersive refraction at the low altitudes, at which observations are necessarily made with small phase angles, produces an unsymmetrical illumination of the slit when guiding is done upon the visual image while the spectrograms are taken in the violet. To make a definitive test two series were obtained in 1920-21 consisting of 41 spectrograms with Venus east, phase 43° to 92°, and of 44 spectrograms with Venus west, phase 107° to 25°. In these observations a ray filter was used in the guiding telescope so that the observer was able to keep the photographic image symmetrically placed upon the slit. Twenty lines have been measured on the 85 spectrograms, and their wave-lengths compared with the mean values from 66 similar spectrograms of skylight. In the former series with guiding on the visual image the wave-lengths from spectrograms taken at low altitudes were systematically shorter than those from spectrograms taken at high altitudes. In the present series with guiding on the photographic image the difference is practically zero. The mean wave-length for 37 spectrograms, mean altitude 14°, *minus* the mean wave-length from 48 spectrograms, mean altitude 28°, is +0.001 A, a quantity within the limit of the errors of observation. The crucial test for variation with the angle Venus-Sun-Earth is a comparison taken with constant altitude and increasing angles, V-S-E. For 37 spectrograms at altitudes of 18° or less the comparison gives very definite evidence against a shortening of the wave-lengths in sunlight from the solar hemisphere turned away from the earth.

V-S-E	Altitude	λ Venus minus λ Skylight	No. of Plates
42°	15°	—0.001 A	9
52	13	—0.002	6
74	15	—0.002	8
96	13	+0.000	4
125	13	0.000	10

The 85 spectrograms furnish a body of data for a determination of solar parallax and a study of the rotation period of Venus. The data will be discussed for these purposes when the measurements are completed.

(To be continued.)

MARY W. WHITNEY.

By CAROLINE E. FURNESS.

(Continued from page 608, Vol. XXX.)

Two years later both the mother and the invalid sister had died, and henceforth Miss Whitney found her greatest happiness in her work. Her first love, as she said more than once, was pure mathematics and its corresponding branch in astronomy, celestial mechanics. The problems of practical astronomy, with their consequent observation and reduction, did not attract her at first, but the breadth of the subject when once she became immersed in it, especially the new branch of astrophysics, which she followed almost from its beginning, appealed greatly to her imagination and in the end she did not regret the work which had fallen to her lot.

Definite work began in the fall of 1894 with observations of comets and asteroids as the principal part of the program. In preparation for the work on minor planets, the writer, whose home was in Cincinnati, spent a few evenings at the observatory with Professor Porter who was one of the leading observers in that line. Like Safford, he remained always a generous friend and furnished us many times with positions of comparison stars until the Gesellschaft zones were all finally issued. To facilitate our observations, a new filar micrometer was ordered from Warner and Swasey to replace the old one which dated from 1865.

An effort was made to take up the study of variable stars, but the aids to identification were so inadequate at that time, that it was given up. However, it gave occasion for a visit to one of the early masters of the art, Mr. Henry M. Parkhurst of Brooklyn. Parkhurst, like Burnham, was a court stenographer, and variable stars were his avocation. His study was in a small upper room and was filled with the paraphernalia of his work. Desk and tables were buried in papers, but his drawings and figures were neatness itself. His wife seemed almost more pleased at our visit than Mr. Parkhurst himself, con-

sidering it a deserved tribute to one who seemed to receive very little recognition for his labors. She listened most devotedly to our conversation and insisted on treating us to cake and tea before we left. It meant more of a journey to go to Brooklyn in those days than it does now.

By this time, astronomers were beginning to take notice of the ambitious women at Vassar. Dr. Gould telegraphed begging for observation on a certain comet for the *Astronomical Journal* and said in a letter, "I wish to congratulate you on the useful service your observatory is doing in these observations of asteroids which you are so persistently following." Astronomical visitors found their way to the vine-clad observatory. Among the first was Professor Safford and his wife, who spent several days at Vassar while he looked over the instruments. Professor Young came for a course of three lectures on the New Astronomy and gave advice on the purchase of a spectroscope. In 1895, Percival Lowell lectured on Mars, winning all the young hearts in his audience by his gracious and debonair manner. In the reception afterwards at the Observatory, he quite shocked the little maid in attendance by hanging his hat on the telescope. This was sacrilege, indeed, to one who had been trained by Professor Mitchell to regard it almost with reverence. Not long after there came Mr. George E. Hale, a new light in the astronomical world from the Kenwood Observatory.

In 1896, contact was made with the astronomers at Columbia University which led to a great widening of the Vassar horizon. The era of photography had arrived and the Columbia Observatory had already undertaken work in the new branch. They had acquired the well known Rutherford collection of cluster plates, which were among the earliest celestial photographs taken in America. A special fund had been provided for their measurement and reduction, and the problem was in charge of Professor Harold Jacoby, who was a member of the International Astrographic Congress. Jacoby also had on hand a set of twelve overlapping plates of the north polar region which had been made for him by Donner at Helsingfors. The question of how faithfully the photographic plate represents the sky was vexing astronomers then, just as it does now, and Jacoby's purpose was to study the optical distortion of the Helsingfors objective by means of these plates.

Four of his plates had been measured by Mrs. Jacoby and Mrs. Davis, whose husband, Herman Davis, was then a member of the Columbia Staff, but there were no funds for the completion of the problem. Professor Jacoby invited the astronomers at Vassar to a conference and suggested that we take up this piece of work and that the writer enter Columbia as a candidate for the Ph. D. degree. His suggestion was acted upon. A Repsold measuring machine was added to the Vassar equipment, the joint gift of Miss Catherine Bruce and Mr. F. F. Thompson, a trustee of Vassar and familiarly known as

"Uncle Fred." Regular work on the reductions was begun at once and the results were eventually published, as will be described later.

In the course of our conference with Jacoby, he stated that he had great difficulty in securing suitable persons to do the measuring and computing on the Rutherford plates, and inquired if we knew of any young college women who were trained in astronomy and mathematics who would be interested in that kind of work. The young men whom he had tried did not seem to care much about it, and were not very diligent workers, and he wondered if women would not be more efficient. It might seem something of an innovation, but women were acting as computers elsewhere, and were examining photographs of the sky at the Harvard Observatory. While the work at Columbia would be very exacting, requiring precise measurements and accurate computations carried on day after day, there was no reason to suppose that properly qualified women could not be found to do it.

It chanced fortunately that we knew of just the person he wanted, Dr. Florence Harpham, a graduate of Carleton College, then teaching at Smith, who had been a fellow student of the writer one summer at the University of Chicago. She went to Columbia the next year, and became eventually the head of a regular computing bureau, the first of its kind in America. Other members of it were discovered at Vassar in an interesting way. Uncle Fred, already referred to, had provided a work fund which could be utilized by the different departments in employing student help. With its aid we had already tried several girls on our reductions with success, and had come across more than one with a decided gift for computing, and three of them went to Columbia.

When it became known in one way and another, that here was a source of workers who were interested, intelligent and reliable, astronomers took their pick, and a procession of Vassar graduates went to many of the leading observatories of America: Yerkes, Lick, Mount Wilson, Allegheny, University of Virginia, and Harvard, to be followed by women from other colleges. It seems to the writer no exaggeration to say that without such assistance as this, the science of astronomy would not have made the wonderful progress it has during the past twenty-five years in America. In discovering such talents and in giving them preliminary training, Miss Whitney made a greater contribution to astronomy than she had any conception of.

In 1897 two thrilling events occurred to disturb the quiet routine of the life at the Vassar College Observatory. The first was the meeting of the British Association for the Advancement of Science, held in Toronto during the summer, where we saw and heard such distinguished British scientists as Lord Kelvin, Lord Lister, Ramsay, Oliver Lodge, James Bryce, Lloyd-Morgan, with such Americans as Simon Newcomb to fill up the galaxy of stars.

Even more exciting was the trip to Williams Bay, to the dedication

of the Yerkes Observatory. Hesitating a little over the invitation, not knowing whether women would really be welcome, but fortified by Miss Cunningham of Swarthmore, we plucked up our courage and accepted it. We three were entertained by Mrs. Wilmarth of Chicago, who opened her house on the lake especially for us, and each day a private yacht waited upon us to transport us to the Observatory. Who could forget the events of that first evening, as we landed at the old Y. M. C. A. pier in the pitchy darkness, and, led by a lantern bearer, walked in single file, picked our way along a rough path and up a steep hillside to the plateau, where we saw the great dome looming over us, and heard its rumbling. To enter the octagonal hall, and see groups of strange faces, each of which probably belonged to some famous astronomer whose name was perfectly familiar to us, was like the fulfillment of a dream. What an eerie feeling it gave one, to see the long telescope tube pointed heavenward, and take one's place in line for a glimpse through it. It was a solemn occasion, almost too wonderful to be true!

The social informality of the occasion was delightful, and if we seemed more serious, and less unbending than our confrères, it was because we were not yet sure of the place which women held in the astronomical world and did not dare to be unscientific or frivolous even for a moment.

About this time an interesting correspondence took place in which Dr. Arthur Auwers took a large part. Professor Whitney was advised by several of her friends to apply for membership in the Astronomische Gesellschaft, and accordingly her application was forwarded to Auwers, indorsed by such men as Safford, Young and Jacoby. In acknowledging it, Auwers said in part: "I received yesterday your application for membership of the Astr. Ges., and today I have forwarded it to the President, Professor Seeliger of Munich. He will bring the matter before the Council . . . I beg to say that I do not belong to the Council, and cannot therefore exercise any influence over their decision. Myself, I do not find objection to ladies working in Astronomy becoming members of the Society, either in the by-laws or in logical reasoning. But on this planet, matters are not always decided by logical reasoning."

Considerably later Auwers sent information that the Council found the admission of ladies incompatible with the by-laws and added, "I can not agree in the opinion that the membership of ladies is forbidden in the by-laws when speaking of 'Astronomen' which as I judge the case, may be ladies equally well as men."

The year 1899 was marked by a second trip to Yerkes to another astronomical conference at which the American Astronomical Society was organized, to which Vassar gave two charter members. In 1900, there was the total solar eclipse of May 28th, which we saw from Wadesboro, one of us using Miss Whitney's three-inch telescope

which had travelled to Burlington in 1869. This year the first regular publication was issued from the Observatory, which was based upon the four 90° plates of the Helsingfors polar set which has already been referred to. It was distributed to the principal observatories of the world, and received gratifying commendation. The funds for both printing and distribution were provided by Mrs. Mary Thaw Thompson, who with other members of her family has always been such a patron of astronomy.

In 1901, the appearance of Nova Persei revived Professor Whitney's interest in variable stars, and thereafter she gave most of her attention to that line of research, rather than to the observation of asteroids. That summer we went abroad to visit some of the principal European observatories and meet European astronomers. Descriptions of buildings and instruments are easily obtained from publications, but little personal touches of the men who use them are more interesting to the reader, and the writer makes no further apology for introducing them here.

Landing at Hamburg, our first visit was to the Potsdam Observatory, where we saw Scheiner and Müller, two very pleasant plump gentlemen who smiled at us most benevolently, and submitted gracefully to having their pictures taken. Our next visit was a real pilgrimage, and took us to the ancient city of Prague and the old observatory of Tycho Brahe. Here the Weineks received us most cordially, showing us Tycho's fine old instruments, and taking us up to the high balcony upon which he used to draw out his sextant. From it we had a wonderful outlook over the city. There was such a vast extent of red tiling, which billowed over the roofs, almost like the waves of the sea, red of every hue, bright new in spots, but mostly old and weather-stained, a novel and fascinating sight to an American who had never seen an old European city. Our hosts urged us to stay to luncheon, which they ended with "gefrorenes" as a special treat to our American palates. They also brought out for our inspection two young lassies with long braids, who dropped charming little courtesies, and greeted us diffidently in English. It happened that one of the great "Sokols" was going on in Prague at the time, and the city was hung every where with long banners of red and white bunting, the colors of old Bohemia. To avoid the crowd, the Weineks took us to an old park, the Belvidere, which Tycho used to visit often in company with the Emperor Rudolph.

A letter to Professor Max Wolf we sent to him immediately upon our arrival in Heidelberg, and much to our surprise he called upon us in person at our hotel to arrange for a visit to Königstuhl. It quite mystified the management that such an august personage, a real "Geheimrath," should call upon two foreign ladies, especially ones who had rooms on the topmost floor. At their rooms in the observatory, Mrs. Wolf came in to talk to us, and soon after a curly-headed little fellow, not more than three years old, stole quietly in, and stand-

ing by a chair looked up at his jovial father, and said in a meek childish voice, "Darf ich hier sitzen, Papa?" He was just the right size for a good hug. They were both very much interested in Vassar as a typical American college for girls, and asked many questions about the work done by its students.

In Strassburg we almost failed to see Professor Becker, because we neglected to send our indispensible letter of introduction in advance. The factotum at the gate insisted that we wished to see the Frau Professorin but Dr. Kobold, who overheard our arguing, came to the rescue, and took us to the Herr Director.

At the Paris Observatory we met Dr. Loewy, the Director, but were especially pleased to see Dorothea Klumpke who had made such a name for herself by her work on the theory of Saturn's rings. She was in charge of the reduction of the Paris astrographic plates, and we were interested to compare her computing bureau with the one at Columbia. She offered to escort us to Meudon to visit the venerable Janssen, an invitation which we were delighted to accept. We were charmed with his picturesque dwelling, made from the stables of the old chateau, with its low-ceiled rooms and quaint winding passages. They made a fascinating setting for the indomitable old Frenchman, who in spite of his eighty years, was planning to make another ascent of Mont Blanc that summer, even if he had to be carried to the summit in a chair. He also asked many questions about the college in America where young girls studied mathematical astronomy. Twenty years ago, the American college girl was an almost unknown specimen of humanity to the European, but the whirligig of time has brought the world war, and her activity in the relief work has made her one of our greatest assets in the eyes of the weary peoples of Europe.

In London, there were the Clerkes and the Hugginses. The two Miss Clerkes, Agnes and Ellen, had asked some friends to meet us at tea in their home in Redcliffe Square. Such a charming personality Miss Agnes had, so gentle, so modest, and yet so full of knowledge. After tea was over some one suggested music. Miss Ellen rose, and picking up her guitar which was standing in the corner, slung the red ribbon over her shoulder and played the accompaniment, while Miss Agnes beat time with her hand, and they sang together some simple melodies in their thin old voices. It was a lovely picture of English life.

Who-on visiting the Hugginses for the first time and approaching the long row of houses on Upper Tulse Hill could imagaine what a wealth of beauty and poetry lay hidden behind those monotonous piles of red brick! There could not be a more picturesque old couple, he with his soft white beard and poetical dark eyes, and she with her halo of short gray hair and gentle voice. He a musician and she an artist, it was not merely a mutual interest in astronomy which drew them together. Their house was filled with artistic treasures. In the library which opened through long windows upon a flower garden, he showed

us his violin, a valuable one, and told us he was the owner of a genuine Stradivarius. She brought out a replica of the Jewel of King Alfred, the original of which was on special exhibition in the British Museum with other relics of the great Saxon King whose millenial anniversary was being celebrated that year.

Their garden, Lady Huggins explained in a delightful manner, going from plant to plant, held nearly all of the flowers mentioned by Shakespeare. She was most charming in pointing out her bee-hive, which is immortalized to the world in the initial letter of the second chapter in their work on stellar spectra. It was an old fashioned straw hive, nicely adjusted to the needs of its tiny industrious occupants. She even kept fresh water for them to drink, with pebbles standing in it here and there, so they might light and drink without getting their feet wet. "Bees must have water," she said in her gentle voice, "and it would be hard for them to find it in London." The motto she had chosen for the hive was "Nil nisi Labore."

In London there was also the Greenwich Observatory to visit, and in Cambridge we saw Sir Robert Ball, and arranged to have him lecture at Vassar on his forthcoming visit to America.

In the winter of 1902 a pleasant incident happened which gave a final status to the position of women in the American Astronomical Society. The annual meeting was held in Washington in connection with the A. A. A. S. and it was planned to have a dinner. Notification blanks were sent out, and after some hesitation the invitation was refused with an intimation that perhaps the presence of women was not desired, that being the custom in several of the other scientific societies. A prompt response came from Professor Newcomb, the president, which settled the question permanently.

"I am much disappointed to notice that although you hope to be here at our meeting, you do not propose to join in the dinner. Possibly you may be under a misapprehension, supposing that the dinner is only for the men of the society. Permit me, therefore to assure you that all members are equal, and that we should like very much to have our lady members with us."

For a number of years, graduate scholarships were maintained at Vassar, and several of the holders took work in astronomy, producing results which were worthy of publication. Two of them computed the definitive orbit of comet 1826 II, a difficult piece of work, because all of the constants had to be deduced from the original tables. They used Newcomb's Tables of the Sun, being among the first to do so, as Leverrier's had generally been used up to that time. Also, the Bauschinger tables, then just published, were used as the basis of the independent star numbers. For this difficult piece of work which appeared in 1905, they received a prize from the Astronomische Gesellschaft of one hundred marks, and by a queer freak of fortune, the

letter announcing the award was written by Seeliger, who ten years earlier had been so opposed to admitting women into the society.

In 1903 a grant from the Carnegie Institution, No. 45, was awarded for the measurement and reduction of the remaining eight plates of the Helsingfors set, the results of which comprised Publication No. 2 of the Vassar College Observatory. Professor Whitney meantime was devoting herself particularly to variable stars. She used a photographic wedge photometer on the twelve-inch telescope, but frequently observed by the Argelander method with a five-inch Clark glass which was very conveniently mounted and housed. This telescope, by the way a very fine one, had been given to the Observatory by Miss Cora Harrison of the class of 1876 who was one of Professor Mitchell's pupils. Ir the summer time, Miss Whitney usually took her own three-inch telescope with her to Waltham and followed variables which were passing through their maxima. SS Cygni was one of her favorites. The discovery of SX Draconis is to be attributed to her. The observations of variable stars made at Vassar during her directorate were edited by the writer and constitute Publication No. 3 of the Vassar Observatory, appearing in 1913. The last few pages of it contain a list of all the articles and publications issued from the Vassar Observatory while Professor Whitney was in charge. They number 102.

In 1907 after the reduction of the Helsingfors polar plates was completed, we were considering what to undertake next in the way of photographic work when Kapteyn's first pamphlet on the "Plan of Selected Areas" appeared. This project seemed a most suitable one in which to co-operate, and as the writer was expecting soon to take a semester for study, Professor Whitney arranged with Kapteyn for her to spend it working under his direction in his laboratory in Groningen where she went in February 1908. In June of that year, which was the fortieth anniversary of the graduation of Miss Whitney's class, their re-union was held in the Observatory. While at supper, word was brought that the husband of one of their deceased members wished to give the college a thousand dollars in the name of the class, and asked them to designate the purpose for which it would be used. With one accord they turned to Miss Whitney to inquire if she needed it in her work. She told of the stereo-comparator which Kapetyn had advised her to get with the expectation of using it in the determination of proper motion. He had agreed to secure suitable plates for the research and would arrange with Donner to make duplicates of some regions of the astrographic plates which had been taken ten years earlier. The class was only too glad to have the gift used for this purpose, and the instrument was ordered from Zeiss. However, so many improvements were incorporated in it, that it was not finished for three years, and by that time the price had increased, and Miss Whitney gave an additional sum herself.

The summer of 1908 she went to England with her niece to meet

the writer after her stay in Groningen, and together we spent a leisurely two months in the lovely English country. There was a short visit to London, and a second trip to 90 Upper Tulse Hill where we saw the Hugginses once more, more lovely and also more frail than at our first visit. Our last glimpse of them as we walked down the hill showed them standing in the doorway waving farewell. Her bright red cape, his dark velveteen jacket, and the two silver heads made a picture that will never fade.

On this trip we visited the two observatories in Oxford, and tried also to meet Sir David Gill, but were not able to make connection with him.

In December 1909 the A. A. A. S. met in Boston which proved to be the last meeting Professor Whitney attended. For her there was to be no co-operation in the survey of the heavens. In the following March she was stricken as her sister was and became an invalid. Ten years of inactivity awaited her which required all of her fortitude to bear, until in January 1921 she died, being in her 74th year.

Reference has already been made to Professor Whitney as a teacher. At first she followed Miss Mitchell's plan of making her courses strictly mathematical, but as the college grew larger, and new departments such as economics were added, the number of students wishing to take a purely mathematical course in astronomy diminished very greatly. Miss Whitney had already been giving a one hour lecture course in descriptive astronomy, and a two hour course in astrophysics, the latter being one of the first of its kind to be offered to undergraduates in America. These she combined and enlarged so as to make a three hour course in descriptive astronomy running through the year, which made a very popular elective. Miss Whitney was equally successful as a lecturer in this line. Not only was her thought clear and logical, but she had a wide and well trained imagination, and a remarkable gift of language, so that she was able to present a distinct and vivid picture to her students. So much admired was she that many students entered her class merely for the sake of having some personal contact with her.

In 1906 enough material on the subject of variable stars had been accumulated to warrant offering a course on that subject, and as far as the writer knows this also was the first regular course to be offered in this subject. After a few years experience, it was incorporated into a book by the present writer.

In her will Professor Whitney left a sum of five thousand dollars to the College for the benefit of the astronomical department, the income of which is to be used solely for research work.

As a member of the Faculty at Vassar, Miss Whitney was held in high esteem both by the President and her colleagues, particularly for her clear thinking and disinterestedness. The following is a quotation from the resolution presented to the Faculty upon her death: "It is

not too much to say, that when she retired there was no member of the Faculty who was held in so much affectionate honor as Mary Whitney. She was in intellect and character the finest type of New England woman; in intellect, steadfastly devoted to truth; in character, as steadfastly holding to the highest ideals, with a gentle humanity and forgetfulness of self that made her a sincere friend of every one."

Another tribute was written by a prominent member of the Faculty not an alumnae: "I shall never forget the impression made upon me, when in 1906, as an instructor attending my first faculty meeting, I saw Professor Mary Whitney writing down in her capacity as Secretary of the Faculty, the record of the College. She represented in herself the finest and best product of her Alma Mater,—in breeding, in courtesy, in scholarship, in tolerance, in generous appreciation of the work and aims of younger women . . . . . Herself a scholar and intellectual woman of the highest type, she constantly by precept and example spurred us all to better work. Her contribution to the traditions of Vassar College in that regard alone is beyond precise knowledge; it belongs to the priceless treasures of the spirit."

Of Miss Whitney's activity as an alumna, something has already been said. In the early days of the College she was one of the leaders in organizing the alumnae along lines helpful to it, but after she became Professor of Astronomy at Vassar, she relinquished this work to younger hands, devoting her energies entirely to her work. Nevertheless she attended the meetings and was frequently called upon to speak and represent the College in public.

What she stood for to the early graduate who was fellow student and friend may be seen from the following tribute from a member of the class of 1870: "Hers was indeed a rare nature. Sane and well-balanced, she brought to every question a wise judgment and a broad and mellow spirit. She sought the truth only, and was ever ready to consider a new presentation of truth. A fine sense of humor and a warm interest in those around her, made her a delightful companion. That which she called a natural faith gave her a pervading and abiding serenity through all the affairs of life."

What she meant to those who were her pupils can be gathered from a touching incident connected with the recent campaign of Vassar for a three million dollar salary endowment fund. Every class had its quota assigned, and though every living member of '68 had done her utmost, they still lacked several hundred dollars. About two weeks before the end of the campaign it was suggested to the writer that an appeal might be made to some of her Vassar friends to make up the amount which was lacking. Accordingly a circular letter was sent to about two hundred of her former pupils asking for small contributions to a memorial fund for her. Though every one was already pledged to the utmost, letter after letter came with more than the sum asked for until the necessary amount was over-subscribed. A

few quotations will show how she was regarded. From a member of '89: "One cannot lose the opportunity to add one's mite to any cause that honors Miss Whitney. Many of us are increasingly grateful to her as the years go on." '94 speaks of "Dear Miss Whitney whose influence at the College was always the finest and most gracious that a girl could have." From 1900, "I offer this small tribute with utmost sincerity to the memory of one whose fine personality still influences me."

One friend of her girlhood days who often saw her in Waltham after she became an invalid said quaintly that she wished she could sit next to her in heaven.

Miss Whitney was always industrious and never wasted her time. For diversion she enjoyed reading, and preferably reading aloud with some congenial companion while sewing was going on. In view of her early surroundings it was inevitable that Emerson should have influenced her thought very greatly. Plain living and high thinking were practiced in her girlhood home in a very real sense. She was fond of Thoreau, Matthew Arnold, Pater and admired Herbert Spencer greatly. Nature poetry like Wordsworth's gave her a deep satisfaction, and she was fond of certain kinds of religious poetry and sermons. In later years her enjoyment of Shakespeare was heightened by the interpretation of Georg Brandes. She was profoundly interested in philosophy and found the writings of Royce most to her liking. She had a great interest in politics and read the "Nation" to the end of her life. It is hardly necessary to state that her belief in suffrage began when she was very young, and that she was keenly interested in everything connected with the progress of women.

Though frequently called upon to write addresses and articles, which she did to the admiration of all, she never cultivated writing for its own sake, but at the urgent request of the writer she wrote a sonnet or two while we were spending a few weeks on the Maine coast just across from Mt. Desert where the natural beauty of the scenery stirred her deeply. The sonnets were never really finished, but they represent so perfectly her feeling toward nature, that one of them is quoted.

NATURE AND LIFE.

"Over the bay the mists of morning lie.
Across, the hazy hills slope from the sea.
Hushed quietness surrounds me. Placidly
The slow waves break, and hardly murmuring, die.
No sound I hear, no motion I espy
Save Nature gives. Into my revery
Falls from afar the thrush's melody.
Ah! this is all I ask,—this,—Nature's peace! I cry.
But no! a boat darts by; with echoing shout
The brown-faced, bare-armed boys pull at the oar.
The farmer's horse beats time along the road.
The mists divide and homestead walls peep out.
Dear human life! we flee thee, yet the more
We crave the touch by thee alone bestowed."

Vassar College Observatory,
September, 1922.

GRAVITATION, IV.

By WILLIAM H. PICKERING.

In our paper entitled Gravitation, III we should perhaps have stated our reason for selecting balls of copper in preference to those of any other metal for our computation. It was of course recognized that specific gravities are not exactly proportional to atomic weights, but they are so more or less for most of the elements, and copper is one of the metals which are heaviest, i. e., that exert the greatest gravitative force, in proportion to their atomic weight. The atoms therefore appear to be packed together more closely in it than in most of the elements. Arranging the more common metals in the order of their specific gravities divided by their atomic weights we obtain:

Nickel	0.150	Zinc	0.109	Aluminum	0.094
Iron	.141	Tungsten	.104	Mercury	.068
Copper	.140	Gold	.098	Tin	.061
Platinum	.110	Silver	.097	Lead	.055

There is only one metal known, glucinum, whose ratio is higher than that of nickel. It has the very high ratio 0.212. For carbon in the crystalline form it is 0.293. There are several of the rarer metals in which the ratio is lower than that for lead. Of these much the most extreme is caesium, 0.014. The heaviest metal, uranium, has a moderate ratio of 0.079, while the lightest substance, hydrogen, in the solid form has a very similar one, 0.077. In general the less the atomic weight, and the more negative the element, the more closely the atoms appear to be packed. In our former paper the number of atoms contained in a sphere one centimeter in diameter was taken as 10^{24}, and this figure was simply assumed to apply to copper. Had we applied it to caesium the gravitative unit would have been much smaller.

In that paper it was stated that when two spheres were in contact half of the lines of force from each would intersect. This is an obvious oversight, since only those lines radiating from the centre of a sphere, and passing through a zone of 60° in diameter centered about the point of contact, could reach the second sphere. Their number is 0.134 of the whole hemisphere. Allowing for the inclination of many of the lines we may take it as approximately 1/8. Since the fraction enters as its square, the attraction of each proton is increased 64 times, and the *unit of gravitational force* becomes 2×10^{-56} dynes. The greatest uncertainty in the whole computation lies clearly in our lack of knowledge of the number of atoms which go to make up a sphere of copper one centimeter in diameter. Our uncertainty on this point is so great that even the exponent —56 may be in error by a few units,

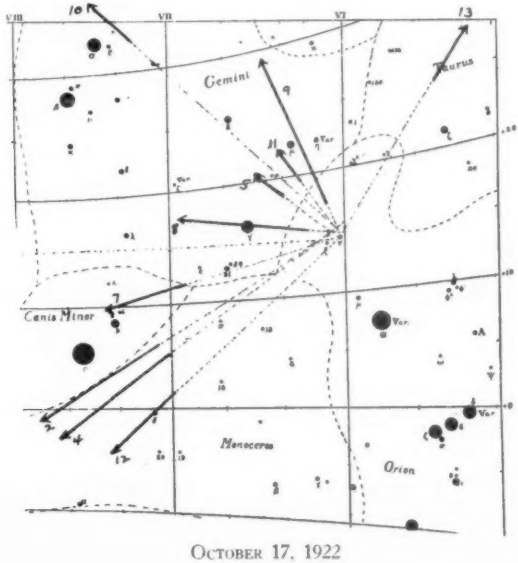
and our result must therefore be taken merely as the first approximation to the true value of the gravitational unit. Until this number is more definitely determined all refinements of computation are evidently worthless.

Mandeville, Jamaica, B. W. I.
October 26, 1922.

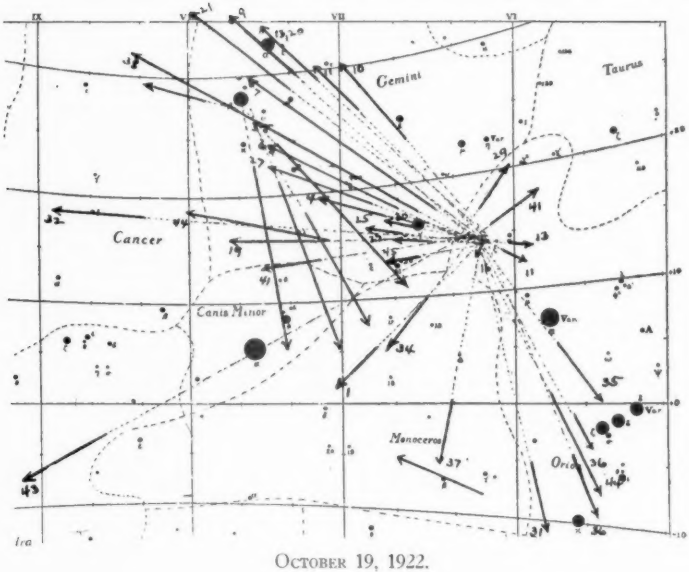
THE OCTOBER METEORS.

By ROBERT M. DOLE.

Weather conditions were almost perfect during October, with brilliantly clear skies, and observations were made on ten different nights from October 17 to 29, 1922. Fresh charts were used each and every night and each meteor was recorded with great care, using two guiding lines at right angles running due east and north, thus giving an especially good line of sight. No reference was made to the work of the previous observation, nor was there the slightest prejudice or preconceived notion of the radiant area. The radiant positions given below have been carefully checked independently by a scientist who got the same results within a fraction of a degree.



OCTOBER 17, 1922

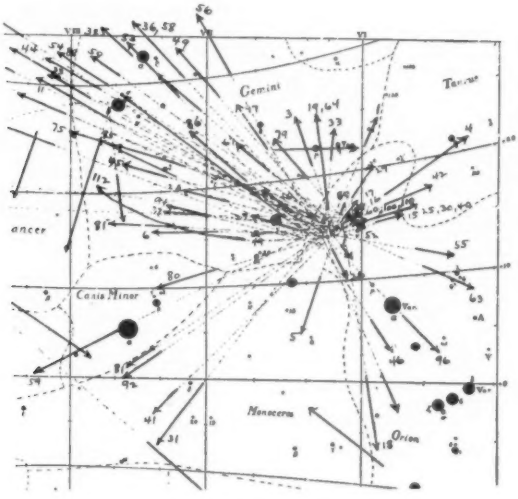


OCTOBER 19, 1922.

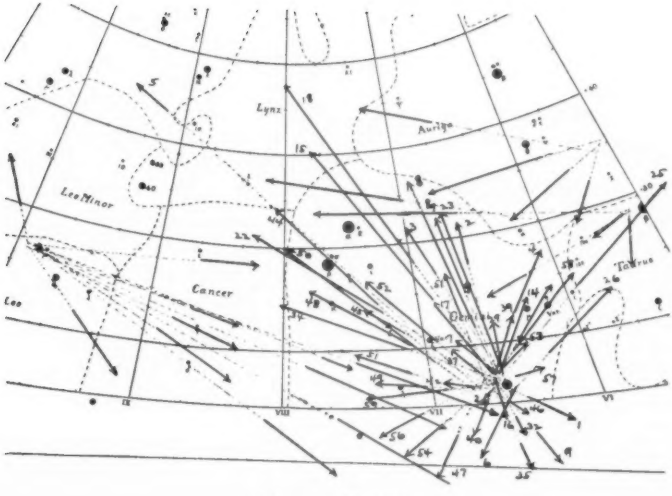
G. M. T.	Radiant R. A.	Dec.	Other Radiants R. A.	Dec.
	°	°	°	°
October 17.9	90.7	+15.0		
" 18.8	91.5	14.8		
" 19.8	93.4	14.8	115.5	+27
" 21.8	93.0	15.1	115.5	+28
" 23.8	95.9	16.8		
" 24.9	99.1	16.6		
" 25.8	99.6	16.6	78.0	+35
" 26.8	100.5	16.8	81.0	28
" 28.8	101.8	20.0	148.5	27
" 29.8	102.8	+19.8	147.0	+25

It was perfectly plain that the radiant area shifted unmistakably, as confirmed by an observer who also got a series covering approximately the same period. In fact no evidence of a stationary radiant was found except on the night of the 23rd, when one or two were observed to radiate from near ν Orionis, and there is reason to believe that this was a group that shifted also. Evidently the radiant area consists of several smaller areas which shift eastwards and that, during the passage of the earth through the richest part of the ribbon, the stream is quite wide.

The Orionids seem to leave comparatively few trains, and as a rule are easy to map, although marked differences were noticed on different nights, both as to speed and length of path. The hourly number varied greatly and it seems that, instead of expecting a maximum on

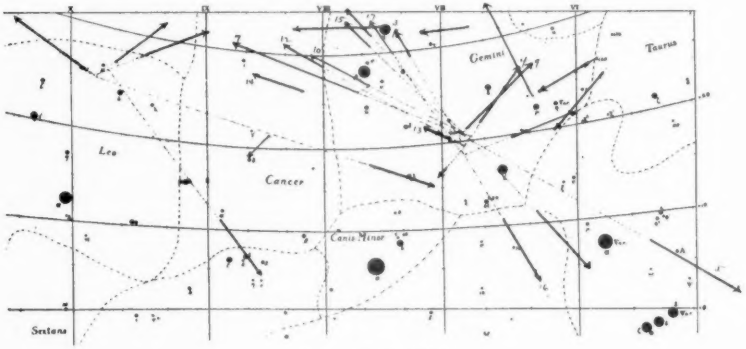


OCTOBER 21, 1922.



OCTOBER 26, 1922.

any one night, it is rather to be found that the maximum may occur between the 18th and 22nd. The greatest hourly number (50) occurred the night of the 21st, while in other years the maximum has occurred on the 19th. Watch was confined to the region around the point of emanation. There were long periods on one or two nights when none were observed, while on the 21st seven were seen in three minutes from a very sharp point.



OCTOBER 29, 1922.

There were a number of distinctly blue and red ones with no very bright individual meteors, rather between 3rd and 6th magnitude. It is believed that curved meteors are very rare, yet several examples were charted, and the observer has noticed in past years that both the Orionids and Geminids occasionally yield a few with curved paths. The sky during the entire series was exceptionally clear.

The Orionid group are of particular interest, and need considerable investigation, and as they come at the pleasantest time of the year, some notable observations are possible. As a spectacle they are always worth watching and seem to persist nearly as long as the Perseids.

352 Orionids were counted during the ten nights' observations divided as follows:

Mag.	—1	0	1	2	3	4	5	6		
No.	1	13	30	46	83	45	63	71	Total 352.	53 left trains.

Sixty meteors were also counted from radiants in Auriga, Leo, Taurus, Gemini and Aries, being quite active when the Orionids were active, showing a possible connection in a way that will bear investigating.

East Lansing, Michigan.
Nov. 1, 1922.

ASTRONOMICAL PHENOMENA IN 1923.

Eclipses.

In the year 1923 there will be four eclipses, two of the Sun and two of the Moon.

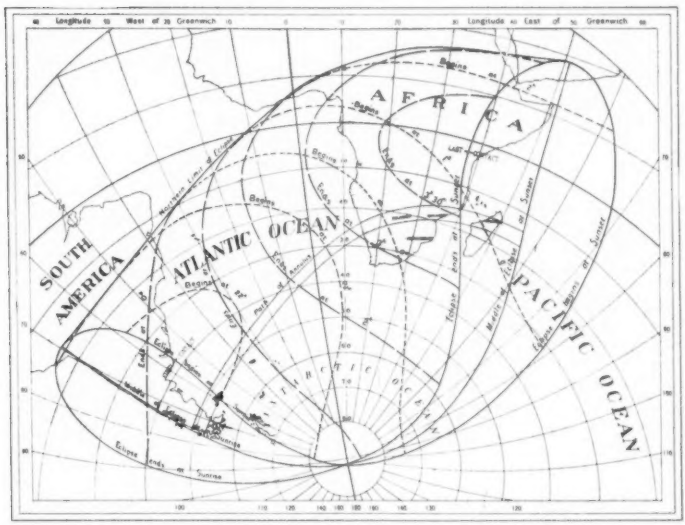
The first of these will be a partial eclipse of the moon on March 2; the beginning will be visible in western Asia, Europe, Africa, the Atlantic Ocean, South America, North America except the northwest portion, and the eastern Pacific; the ending will be visible in Europe, Africa except the eastern part, the Atlantic Ocean, North and South America, and the eastern part of the Pacific Ocean.

The circumstances of this eclipse will be as follows:

	d	h	m	
Moon enters penumbra	March 2	7	12.6 P. M.	C.S.T.
Moon enters umbra	2	8	27.8 P. M.	"
Middle of eclipse	2	9	31.8 P. M.	"
Moon leaves umbra	2	10	35.8 P. M.	"
Moon leaves penumbra	2	11	50.8 P. M.	"

Magnitude of eclipse = 0.376 (Moon's diamter = 1.0).

ANNULAR ECLIPSE OF MARCH 16-17, 1923.



Note:- The hours of beginning and ending are expressed in Greenwich Mean Time.

The second will be an annular eclipse of the Sun on March 17. The central line of the eclipse touches the earth just north of Cape Horn, crosses the southern Atlantic, the southern part of Africa and leaves the earth off the eastern coast of Madagascar. The path is shown in the figure on this page. The circumstances of the eclipse are:

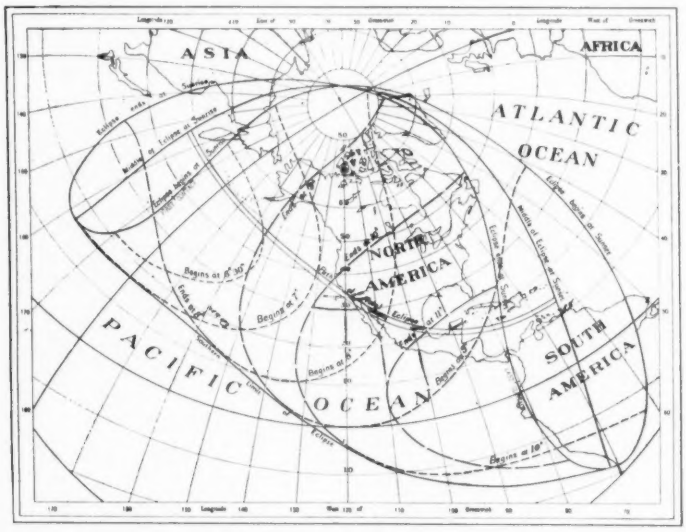
	d	h	m	
Eclipse begins	March 17	3	50.4 A. M.	C.S.T.
Central eclipse begins	17	5	5.5 A. M.	"
Cent. eclipse at local appt. noon	17	6	24.1 A. M.	"
Central eclipse ends	17	8	23.8 A. M.	"
Eclipse ends	17	9	38.9 A. M.	"

The third will be a partial eclipse of the Moon on the morning of August 26. The beginning will be visible in North America except in the northeastern part, the western part of South America, the Pacific Ocean, Australia except the southwestern part, and the extreme northeastern part of Asia; the ending visible in North America except the northeastern part, the extreme northwestern part of South America, the Pacific Ocean, Australia and the eastern part of Asia. The circumstances of the eclipse will be as follows:

	d	h	m	
Moon enters penumbra	Aug. 26	2	12.3 A. M.	C.S.T.
Moon enters umbra	26	3	51.8 A. M.	"
Middle of eclipse	26	4	39.5 A. M.	"
Moon leaves umbra	26	5	27.3 A. M.	"
Moon leaves penumbra	26	7	6.4 A. M.	"

The fourth and last eclipse of the year, a total eclipse of the sun, September 10. The line of totality begins in the western part of the north Pacific, skirts the islands west of Alaska, strikes North America at San Diego, California, crosses Mexico in a southeasterly direction and ends off the northern coast of South America. The figure below shows the path of totality as well as the boundaries of the region where the sun may be seen partially obscured.

TOTAL ECLIPSE OF SEPTEMBER 10, 1923



Note.—The hours of beginning and ending are expressed in Greenwich Mean Time.

The circumstances of the eclipse will be as follows:

	d	h	m	
Eclipse begins	Sept. 10	10	14.4 A. M.	P.S.T.
Central eclipse begins	10	11	16.9 A. M.	"
Cent. eclipse at local appt. noon	10	12	30.2 P. M.	"
Central eclipse ends	10	2	17.4 P. M.	"
Eclipse ends	10	3	19.9 P. M.	"

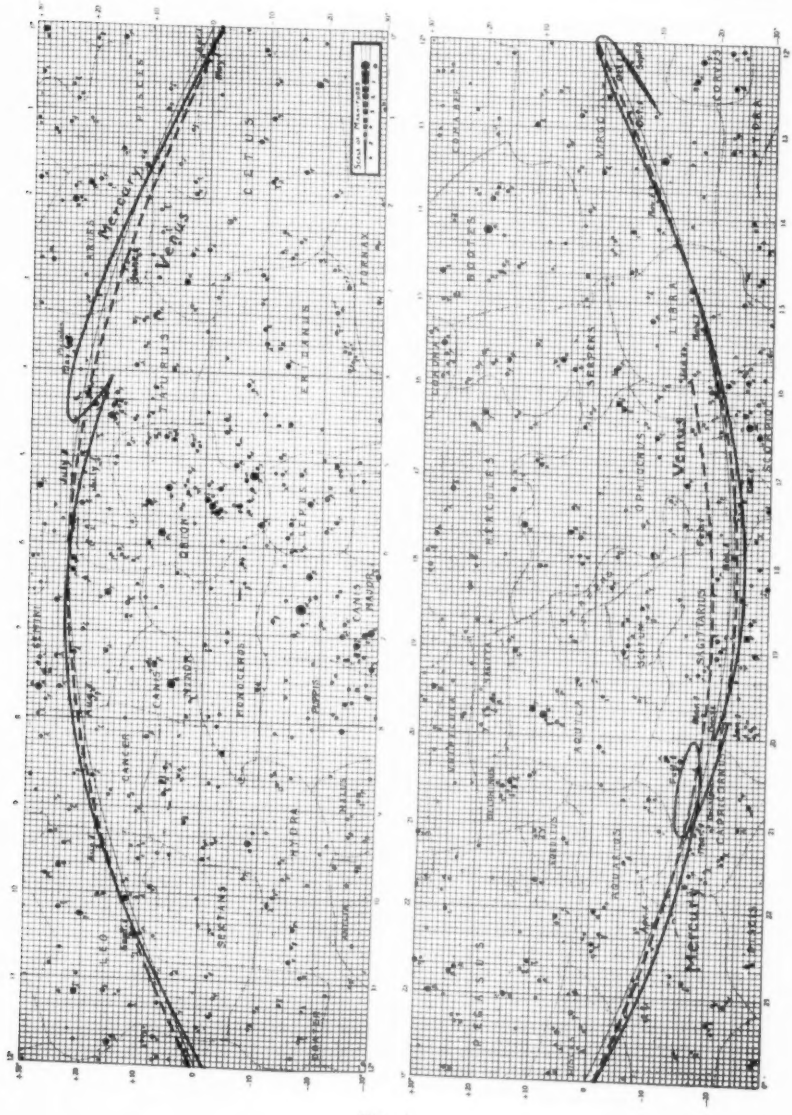


FIG. 1.

Apparent paths of the planets Mercury and Venus among the stars during the year 1923.

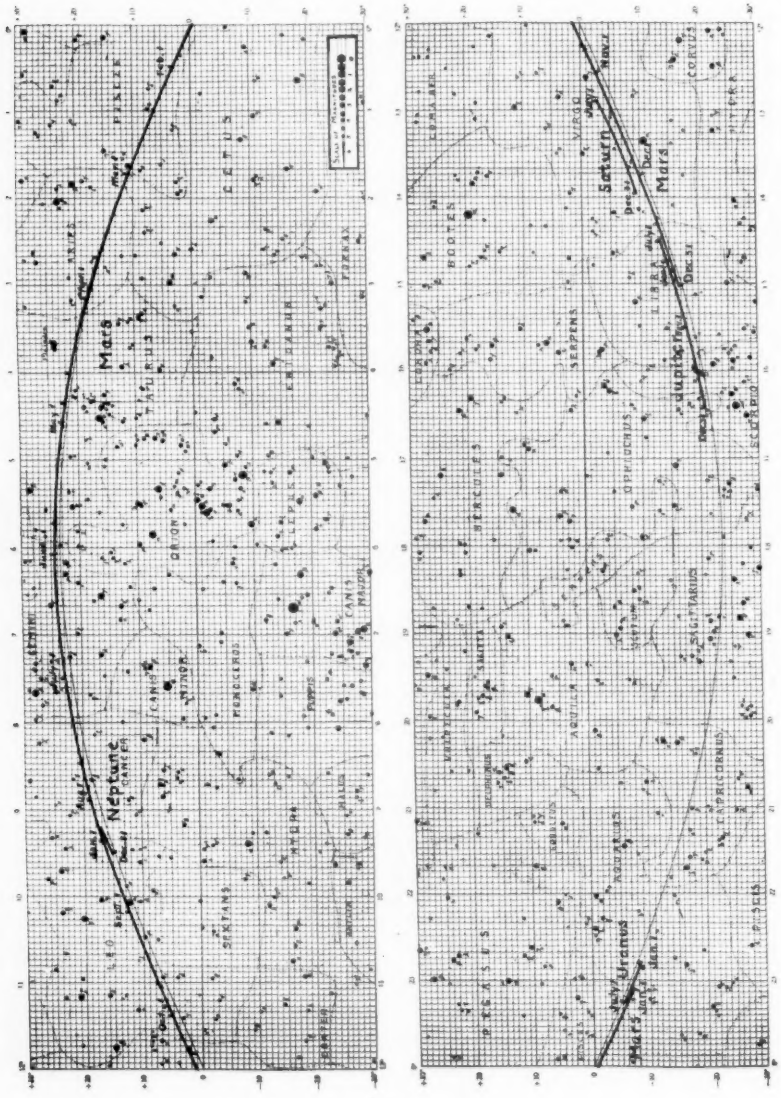


FIG. 2.

Apparent paths of the planets Mars, Jupiter, Saturn, Uranus, and Neptune among the stars during the year 1923.

This eclipse will be of importance to the astronomical world as the path of totality crosses some regions that are easily accessible, particularly along the California coast and in some parts of Mexico. No doubt it will be generally observed by many parties. At a later time we expect to publish more detailed information for the benefit fo those who may be interested in observing it.

We are indebted to the *American Ephemeris* for the circumstances of the various eclipses as well as for the figures on pages 41, 42, 45, and 46.

THE PLANETS.

Mercury will be in the western part of Sagittarius at the beginning of the year and after making the circuit of the heavens will be found very close to its first position when the year ends. The planet will make a loop in Capricornus in February, a reversed figure 2 in Taurus in June and a very narrow loop in Virgo in September.

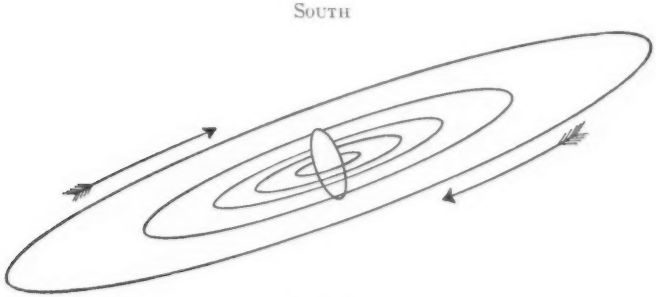


FIG. 3.

Apparent orbits of the satellites of Jupiter at date of opposition, May 5, 1923, as seen in an inverting telescope, and elongated in the ratio of three to one in the direction of their minor axes.

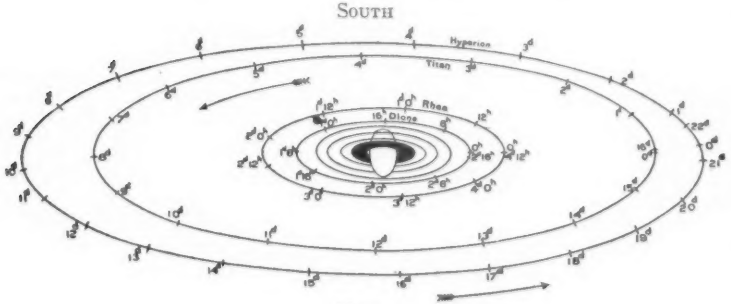


FIG. 4.

Apparent orbits of the seven inner satellites of Saturn, at date of opposition, April 7, 1923, as seen in an inverting telescope, and elongated in the ratio of two to one in the direction of their minor axes.

Venus begins the year in the western part of Libra and after going completely around the heavens will end the year in Capricornus. A singular feature of the path of Venus is that no retrograde motion will occur at any time so that there is not a single loop in the apparent path.

Mars will be in Aquarius on January 1 and will move eastward continuously until it reaches Libra on December 31. The planet will be so far from the earth throughout the year that observations will be very difficult.

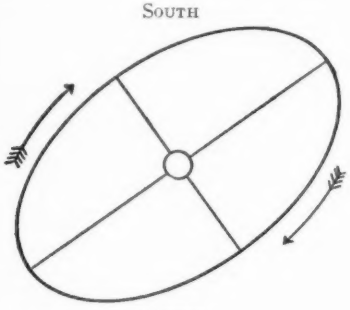


FIG. 5.

Apparent orbit of the satellite of Neptune at date of opposition, February 6, 1923, as seen in an inverting telescope.

Jupiter will spend almost the entire year in Libra. The planet will be moving direct from January 1 to March 5, retrograde from March 5 to July 7 and then direct again until the year closes when it will be about 5° north of Antares. The increasing southern declination of the planet will make observations difficult at observatories in the northern hemisphere.

Saturn will be in Virgo throughout the year. The planet's motion will be direct during January, retrograde until June 17 and then direct for the remainder of the year.

Uranus will spend the entire year in the western part of Aquarius. Its motion will be direct until June 23, retrograde until November 19 and then direct until the summer of 1923.

Neptune begins the year in Leo, retrogrades into Cancer until near the end of April, crosses back into Leo until November 25 and then retrogrades slightly until after the close of the year.

THE COMETS.

Three of the comets of 1922, Baade's *c* 1922, Skjellerup's *d* 1922, and Perrine's periodic comet *e* 1922 may still be visible with large telescopes during the early part of 1923.

The only periodic comet expected to return during the year is that of D'Arrest, which was first seen in 1851 and has been observed at its returns in 1857, 1870, 1877, 1890, 1897, 1910. It was not seen in 1917, being unfavorably situated for observation. In 1920 it made a rather close approach to Jupiter and the ele-

ments of its orbit may have been greatly changed so that it is impossible to predict the comet's place with any precision until the perturbations have been taken account of. So far as we know no accurate ephemeris of this comet has yet been published. Unless the perturbations have been great the comet should be at perihelion about the latter part of September and should be fairly well placed for observation during the summer months.

Meteors.

From time to time very interesting displays may be noted if one has the time for the observations. The dates on which they may be expected cannot always be predicted with certainty so that more or less regular observations are necessary in order not to miss the best displays.

The following table, due to Mr. W. F. Denning, the well-known British authority on meteors, gives the approximate dates on which displays may be expected.

Date	Radiant α	Radiant δ	Average Number
Jan. 2	230°	+52°	18
Jan. 3	230	+52	28
Apr. 20	270	+33	8
Apr. 21	271	+33	9
May 4	334	— 2	6
June 27	213	+53	7
June 28	228	+58	7
Aug. 10	44	+57	48
Aug. 11	45	+57	69
Oct. 19	92	+15	21
Oct. 20	98	+14	20
Nov. 14	150	+22	20
Nov. 15	150	+22	21
Nov. 19	25	+43	15
Dec. 11	111	+33	22
Dec. 12	112	+33	23

Variable Stars.

The tables of short period variable stars with predicted maxima and minima will be published as formerly. The elements upon which the predictions are based are often old and in need of correction. Observers who find the predicted times inaccurate would confer a favor if they would send their own observations to the editors so that the elements could be corrected.

Occultations.

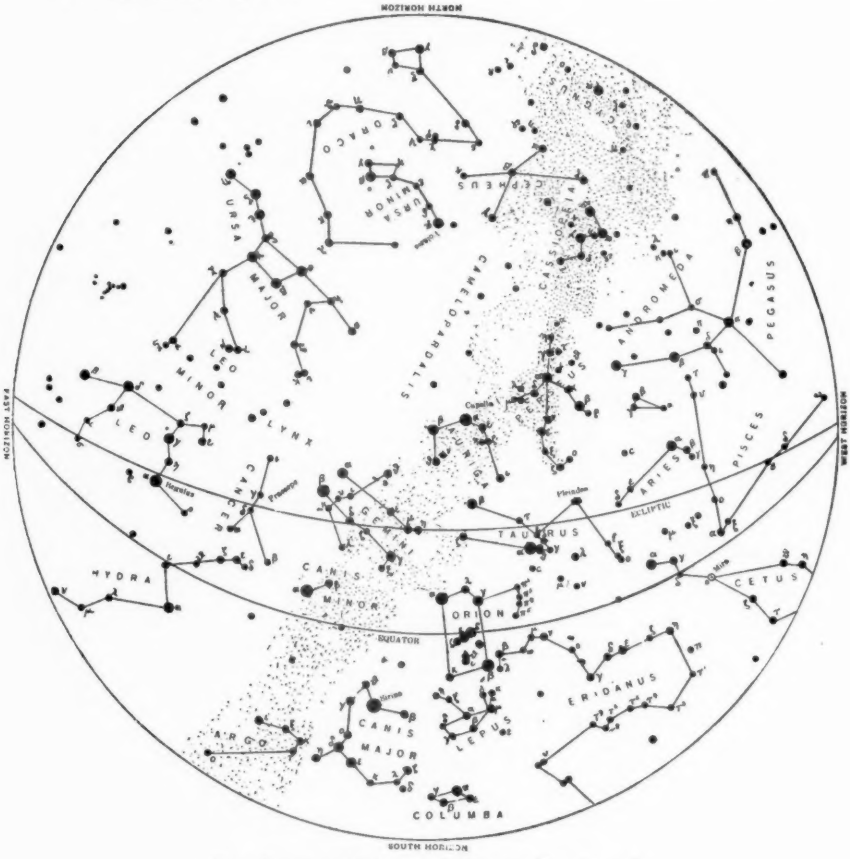
The occultations of special interest will be computed and charts drawn by our valued contributor, Prof. W. F. Rigge. Other occultations will be taken from the *American Ephemeris*.

Satellites.

The satellite diagrams published by the *American Ephemeris* will be found on another page. They will serve in identifying the satellites. Satellite phenomena for Jupiter and Saturn will also be published when these planets are far enough from the sun for easy observation.

PLANET NOTES FOR FEBRUARY.

The *sun* will move eastward from $20^h\ 56^m$ to $22^h\ 42^m$ in right ascension, and northward from $-17°\ 18'$ to $-8°\ 14'$ in declination during February. It will move from Capricornus into Aquarius through a region in which there are no conspicuously bright stars.



THE CONSTELLATIONS AT 9:00 P. M. FEBRUARY 1.

The phases of the *moon* will occur as follows:

Full moon	Feb.	1	at 10 A. M.	C.S.T.
Last quarter		8	" 3 A. M.	"
New moon		15	" 1 P. M.	"
First quarter		23	" 6 P. M.	"

The *moon* will be nearest the earth for the month on February 4, and farthest from the earth on February 20.

Mercury will be too near the sun to be visible at the beginning of the month. Its apparent motion in the sky will be westward until February 9, after which it will move eastward rather more slowly than the sun until February 22 which is a date of greatest elongation west of the sun. Near this date it will rise about an hour before the sun and may be seen on the eastern horizon a short distance south of the rising point of the sun.

Venus will reach a point of greatest elongation west of the sun on February 4. At this time it will be well up in the sky at sunrise and will be very bright. It will be found in about the same position relative to the sun throughout the month.

Mars will still be moving eastward ahead of the sun although somewhat more slowly than the sun. It will be in the constellation Pisces, not near any bright star. Because of its nearness to the sun and its great distance from the earth it will not be well situated for observations during February.

Jupiter will be in quadrature with the sun, 90° west, on February 7. It will therefore be in favorable position for morning observations. It will be in the constellation Libra.

Saturn will be a short distance northwest of Jupiter in the constellation Virgo not far from Spica. It also will be favorably situated in the morning sky.

Uranus will be too near the sun for observations during the month.

Neptune will be in a position of opposition to the sun on February 6. It will be in the constellation Leo, not far from Regulus.

Occultations Visible at Washington.

[*From the American Ephemeris.*]

Date 1923	Star's Name	Magnitude	IMMERSION. Washington M.T.	IMMERSION. Angle from N	EMERSION. Washington M.T.	EMERSION. Angle from N	Duration
			h m	°	h m	°	h m
Feb. 1	ξ Leonis	5.1	12 48	122	14 6	281	1 17
2	48 Leonis	5.2	15 59	91	17 2	317	1 3
3	83 Leonis	6.3	12 56	106	14 12	306	1 16
3	τ Leonis	5.2	13 40	110	14 57	303	1 18
6	κ Virginis	4.3	12 22	147	13 12	256	0 50
23	70 Tauri	6.4	11 38	113	12 32	242	0 54
23	θ^1 Tauri	4.2	13 0	114	13 48	241	0 48
25	124 H.^{1} Orionis	5.7	13 16	38	13 47	334	0 31
27	1 Cancri	6.0	7 17	162	7 51	212	0 34

COMET NOTES.

Baade's Comet.—Three sets of elements of this comet were published in the December number of POPULAR ASTRONOMY. An additional set by Senor José M. Chacón of the Mexican National Observatory, at Tacubaya, based on observations of October 22, 23, and 24 is reported in Harvard College Observatory Bulletin 780, as follows:

$$T = 1922, \text{ October } 10.177 \text{ G.M.T.},$$
$$\omega = 112° \ 3' \ 47''$$
$$\Omega = 219° \ 25' \ 0''$$
$$i = 51° \ 59' \ 56''$$
$$q = 2.2999$$

The representation, O-C, on November 24, according to an observation at Tacubaya by Director Gallo, was $\Delta\alpha = +14^s$, $\Delta\delta = -2'$.

Ephemeris of Comet c 1922 (Baade).—Elements of this comet and an ephemeris derived from them were given in the December issue of POPULAR ASTRONOMY. The following is an extension of the ephemeris given last month.

EPHEMERIS FOR GREENWICH MEAN MIDNIGHT.

		True α h m s	True δ ° ′	log Δ	Br.
1923 Jan.	8	23 02 14	+18 53.3	0.4126	0.48
	9	04 30	46.0		
	10	06 46	38.8		
	11	09 01	31.9		
	12	11 16	25.1	0.4223	
	13	13 30	18.5		
	14	15 44	12.0		
	15	17 58	18 5.7		
	16	20 11	17 59.6	0.4320	0.43
	17	22 23	53.7		
	18	24 35	47.9		
	19	26 46	42.2		
	20	28 57	36.8	0.4416	
	21	31 07	31.4		
	22	33 17	26.2		
	23	35 26	21.2		
	24	37 35	16.3	0.4511	0.38
	25	39 44	11.6		
	26	41 52	7.0		
	27	43 59	17 2.5		
	28	46 06	16 58.2	0.4605	
	29	48 12	54.0		
	30	50 18	49.9		
	31	52 24	46.0		
Feb.	1	54 29	42.1	0.4697	0.34
	2	56 33	38.4		
	3	23 58 37	34.8		
	4	00 00 41	31.4		
	5	02 44	28.0	0.4787	
	6	04 47	24.8		
	7	06 49	21.6		
	8	08 51	18.6		
	9	00 10 52	+16 15.6	0.4876	0.30

Brightness October 29 = 1.00

An observation by Barnard indicates that on Dec. 12 the ephemeris required a correction of —4ˢ in right ascension and 0.0 in declination.

Iowa State University, H. M. JEFFERS.
December 20, 1922.

Skjellerup's Comet. —A cablegram from the Central Bureau of Astronomical Telegrams, at Copenhagen, announces the discovery of a faint comet by Skjellerup, at Cape of Good Hope, in the following position:

November 26.5556, G. M. T.
R. A. 11ʰ 0ᵐ 49ˢ.9
Dec. —10° 43′ 43″
Daily motion, 3ᵐ 40ˢ east; 1° 22′ south.

Two photographs of the comet were made at the Harvard Observatory with the 16-inch refractor on the night of November 28. The diameter of the head is approximately one minute of arc, the integrated photographic magnitude is estimated as 7, and the daily motion is 1°.8.

Harvard College Observatory Bulletin 779.

Skjellerup's Comet. — A cablegram received from the Central Bureau of Astronomical telegrams at Copenhagen gives the following elements and ephemeris of Skjellerup's Comet, (d) 1922, as computed by Wood:—

ELEMENTS.

Time of perihelion passage	(T)	1923. January 1.14 G. M. T.
Perihelion minus node	(ω)	260° 31′
Longitude of node	(Ω)	261° 8′
Inclination	(i)	23° 4′
Perihelion distance	(q)	0.946

EPHEMERIS.

G. M. T.	R. A. h m s	Dec. ° ′	Light
1922, December 4.5	11 43 20	−18 29	1.00
8.5	12 5 48	−22 9	
12.5	12 28 56	−25 35	
16.5	12 52 32	−28 39	1.14

A night letter received here December 6 from Professor A. O. Leuschner, Director of the Students' Observatory, Berkeley, California, states that the elements of Skjellerup's Comet resemble those of Brooks' Comet, 1892 VI, and that the comets are probably identical.

The following photographic position has been received here:—

G. M. T.	R. A. h m s	Dec. ° ′	Observer	Place
December 1.9736	11 29 36	−16 4	Barnard	Yerkes

The comet is of the eighth magnitude.

On a photograph made at Harvard, December 2, with a 1-inch photographic telescope, the integrated photographic magnitude of Skjellerup's comet is estimated at 8.

Harvard College Observatory, Bulletin 780.
Cambridge, Massachusetts, December 5, 1922.

VARIABLE STARS.

Eight New Variable Stars. — The following new variable stars have been found recently on Harvard photographs.

Harvard Variable	R. A. 1900 h m	Dec. 1900 ° ′	Maximum	Minimum	Discovered by
3626	4 45.7	+14 23	12.0	<14.2	Miss Woods
3627	12 54.0	+15 44	13.3	<15.7	Miss Woods
3628	13 3.7	+13 56	12.0	13.8	Miss Woods
3629	13 51.3	+14 38	12.2	14.1	Miss Woods
3630	16 21.3	−25 54	15	16	Bailey
8631	16 21.7	−25 50	15	16	Bailey
3632	16 22.8	−25 37	14	17	Bailey
3633	23 43.4	−70 6	12.3	12.7	Menzel

No. 3628 appears to be a Cepheid variable of the cluster type.

The variables found by Professor Bailey are about one degree from the globular cluster N. G. C. 6144, in a region that lies along the ragged border of the great obscuring nebulosities associated with Rho Ophiuchi. Professor Bailey writes that No. 3630 appears to have a period of about four months, No. 3631 a short period, possibly 2.5 days, and No. 3632 a period greater than five months.

Harvard College Observatory Bulletin 779.

Minima of Variable Stars of Short Period.

[Calculated by members of the class in General Astronomy at Carleton College.]

Given to the nearest hour in Greenwich mean time; to obtain Eastern Standard time subtract 5^h; Central Standard time 6^h, etc.

Star	R.A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of minima in 1923							
					February							
	h m	° ′		d h	d h		d h		d h		d h	
SY Androm.	0 08.0	+43 09	9.5—13.0	34 21.8								
RT Sculptor.	31.5	—26 13	9.6—10.5	0 12.3	7 20		15 12		23 4			
U Cephei	0 53.4	+81 20	7.0— 9.0	2 11.8	7 10		14 21		22 8			
Z Persei	2 33.7	+41 46	9.4—12	3 01.4	4 4		10 6		22 12		28 15	
TW Cassiop.	37.6	+65 19	8.2— 9.0	1 10.3	2 1		10 15		19 4		27 18	
RY Persei	39.0	+47 43	8.0—10.3	6 20.7	7 9		14 6		21 3		29 23	
RZ Cassiop.	39.9	+69 13	6.9— 8.1	1 04.7	2 14		9 18		16 23		24 3	
TX Cassiop.	44.4	+62 22	9.4—10.1	2 22.2	3 20		12 15		21 9			
ST Persei	53.7	+38 47	8.5—10.5	2 15.6	2 7		10 6		18 5		26 3	
RX Cassiop.	2 58.8	+67 11	8.6— 9.1	32 07.6	6 3							
Algol	3 01.7	+40 34	2.3— 3.5	2 20.8	8 22		17 12		26 3			
RT Persei	16.7	+46 12	9.5—11.5	0 20.4	3 5		10 1		16 19		23 15	
λ Tauri	55.1	+12 12	3.3— 4.2	3 22.9	8 15		16 12		24 10			
RW Tauri	3 57.8	+27 51	7.1—<11	2 18.5	5 3		13 11		21 18			
RV Persei	4 04.2	+33 59	9.5—12.0	2 23.4	1 18		9 16		17 13		25 10	
RW Persei	13.3	+42 04	8.8—11.0	13 04.8			12 0		25 5			
SZ Tauri	31.4	+18 20	7.2— 7.7	3 03.6	8 8		17 18		27 5			
RS Cephei	4 48.6	+80 06	9.5—12.0	12 10.1			11 11		23 21			
TT Aurigæ	5 02.8	+39 27	7.8— 8.7	0 16.0	2 5		8 21		22 4		28 21	
RY Aurigæ	11.5	+38 13	10.7—11.7	2 17.5	4 7		12 11		20 16		28 20	
RZ Aurigæ	42.9	+31 40	10.6—13.3	3 00.3	5 11		11 11		17 12		23 12	
SV Tauri	45.8	+28 05	9.4—11.0	2 04.0	8 4		16 20		25 12			
Z Orionis	50.2	+13 40	9.7—10.7	5 04.9	1 16		12 2		22 12			
SV Gemin.	54.6	+24 28	9.8—<11	4 00.2	2 16		10 17		18 17		26 17	
RW Gemin.	5 55.4	+23 08	9.5—11.0	2 20.8	3 20		9 14		21 1		26 18	
U Columbæ	6 11.2	—33 03	9.2—10.0	2 19.2	6 10		12 0		23 5		28 2	
SX Gemin.	22.0	+20 37	10.8—11.5	1 08.8	6 9		14 13		22 18		30 23	
RW Monoc.	29.3	+ 8 54	9.0—10.8	1 21.7	1 8		8 23		16 14		24 5	
RX Gemin.	43.6	+33 21	8.8— 9.6	12 05.0			12 22		25 3			
RU Monoc.	6 49.4	— 7 28	9.8—10.5	0 21.5	7 8		14 13		21 17		28 21	
R Can. Maj.	7 14.9	—16 12	5.8— 6.4	1 03.3	1 20		8 16		22 7		29 3	
RY Gemin.	21.7	+15 52	8.9—<10	9 07.2	5 3		14 10		23 17			
Y Camelop.	27.6	+76 17	9.5—12	3 07.3	2 2		8 17		21 22		28 12	
TX Gemin.	30.3	+17 08	10.0—11.9	2 19.2	1 2		9 12		17 22		26 7	
RR Puppis	43.5	—41 08	9.4—10.7	6 10.3	6 19		13 6		19 16		26 2	
V Puppis	7 55.4	—48 58	4.1— 4.8	1 10.9	6 4		13 11		20 17		28 0	
X Carinae	8 29.1	—58 53	7.9— 8.7	0 13.0	6 13		14 16		22 19			
S Cancri	8 38.2	+19 24	8.2—10	9 11.6			9 3		18 14		28 2	
RX Hydræ	9 00.8	— 7 52	9.1—10.5	2 6.8	3 6		10 2		16 22		23 19	
S Velorum	29.4	—44 46	7.8— 9.3	5 22.4	1 18		7 17		19 14		25 12	
Y Leonis	9 31.1	+26 41	9.3—11.2	1 16.5	5 16		12 10		19 4		25 22	
RR Velorum	10 17.8	—41 36	10.0—10.9	1 20.5	7 0		14 10		21 20			
SS Carinæ	10 54.2	—61 23	12.2—12.8	3 07.2	3 11		11 1		17 16		24 6	
ST Urs. Maj.	11 22.4	+45 44	6.7— 7.2	8 19.2	5 4		14 0		22 19			
RW Urs. Maj.	35.4	+52 34	10.3—11.4	7 07.9	6 18		14 1		21 9		28 17	
Z Draconis	11 39.8	+72 49	9.9—13.6	1 08.6	7 14		14 9		21 3		27 23	
RZ Centauri	12 55.6	—64 05	8.5— 8.9	1 21.0	7 1		14 12		22 1		29 12	
RS Can. Ven.	13 06.3	+36 28	7.5—12.5	4 19.1	3 14		13 5		22 19			
SS Centauri	07.2	—63 37	8.8—10.4	2 11.5	6 6		13 16		21 3		28 13	
133926 Hydræ	13 39.0	—26 23	8.6—12.7	2 21.5	3 15		9 10		21 1		26 19	

Minima of Variable Stars of Short Period—Continued.

Star	R.A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of minima in 1923 February					
	h m	° ′		d h	d h	d h	d h	d h	d h	d h
δ Libræ	14 55.6	— 8 07	4.8— 6.2	2 07.9	1 18	8 18	15 17	22 17		
U Coronæ	15 14.1	+32 01	7.6— 8.7	3 10.9	1 4	8 2	21 21	28 19		
TW Draconis	15 32.4	+64 14	7.3— 8.9	2 19.3	4 19	13 6	21 16			
SS Librae	15 43.4	—15 14	9.3—11.5	0 18.4	7 1	14 5	21 10	28 14		
SW Ophiuchi	16 11.1	— 6 44	9.2—10.0	2 10.7	3 2	10 10	17 19	25 2		
SX Ophiuchi	12.6	— 6 25	10.5—11.2	2 01.5	3 10	11 16	19 22	28 4		
R Aræ	31.1	—56 48	6.8— 7.9	4 10.2	8 13	17 9	26 5			
TT Herculis	16 49.9	+17 00	8.9— 9.3	20 18.1		15 10				
TU Herculis	17 09.8	+30 50	9.5—12	2 06.4	3 3	9 22	16 17	23 12		
U Ophiuchi	11.5	+ 1 19	6.0— 6.7	0 20.1	3 12	12 0	20 9	28 18		
u Herculis	13.6	+33 12	4.6— 5.4	2 01.2	1 10	7 14	19 21	26 1		
TX Herculis	15.4	+42 00	8.3— 9.0	1 00.7	6 17	12 22	19 2	25 7		
RV Ophiuchi	29.8	+ 7 19	9. —12	3 16.5	8 2	15 11	22 19			
SZ Herculis	36.0	+33 01	9.5—10.3	0 19.6	2 22	11 2	19 6	27 11		
TX Scorpii	48.6	—34 13	7.5— 8.2	0 22.6	4 9	11 22	19 11	27 0		
UX Herculis	49.7	+16 57	8.8—10.5	1 13.2	1 18	9 12	17 6	25 0		
Z Herculis	53.6	+15 09	7.1— 7.9	3 23.8	4 15	12 15	20 4	28 14		
WX Sagittarii	53.6	—17 24	9.2—10.8	2 03.1	5 5	13 18	22 6			
WY Sagittarii	17 54.9	—23 1	9.5—10.6	4 16.0	**9 23**	19 7	28 15			
SX Draconis	18 03.0	+58 23	9.3—10.5	5 04.1	3 16	14 1	24 8			
RS Sagittarii	11.0	—34 08	5.9— 6.3	2 10.0	5 7	12 13	19 19	27 1		
V Serpentis	11.1	—15 34	9.5—11.1	3 10.9	6 10	13 8	20 6	27 4		
RZ Scuti	21.1	— 9 15	7.4— 8.3	15 03.2	1 16		16 19			
RZ Draconis	21.8	+58 50	9.5—10.2	0 13.2	4 20	12 0	21 4	26 8		
RX Herculis	26.0	+12 32	7.0— 7.6	0 21.3	6 15	13 17	20 20	27 23		
SX Sagittarii	39.7	—30 36	8.7— 9.8	2 01.8	5 10	13 17	23 0			
RR Draconis	40.8	+62 34	9.3—13	2 19.9	5 3	13 14	22 2			
RS Scuti	43.7	—10 21	9.3—10.3	0 15.9	5 10	12 2	18 17	25 9		
β Lyræ	46.4	+33 15	3.4— 4.1	12 21.8		13 8		26 6		
U Scuti	18 48.9	—12 44	9.1— 9.6	0 22.9	2 19	10 10	18 1	25 17		
RX Draconis	19 01.1	+58 35	9.3—10.2	1 21.4	7 8	14 22	22 12			
RV Lyræ	12.5	+32 15	11. —12.8	3 14.4	2 18	9 22	17 3	24 8		
RS Vulpec.	13.4	+22 16	6.9— 8.0	4 11.4	7 22	16 23	25 22			
U Sagittæ	14.4	+19 26	6.5— 9.0	3 09.1	4 12	11 7	18 1	24 19		
Z Vulpec.	17.5	+25 23	7.3— 8.5	2 10.9	1 22	9 6	16 15	24 0		
TT Lyræ	24.3	+41 30	9.4—11.6	5 05.8	6 0	10 8	20 20	26 2		
UZ Draconis	26.1	+68 44	9.0— 9.8	1 15.1	4 5	10 18	17 7	23 19		
SY Cygni	19 42.7	+32 28	10. —12	6 00.2	3 19	9 19	21 19	27 20		
WW Cygni	20 00.6	+41 18	9.3—13.4	3 07.6	3 4	9 19	16 11	23 2		
SW Cygni	03.8	+46 01	9. —11.7	4 13.8	1 14	10 17	19 21			
VW Cygni	11.4	+34 12	9.8—11.8	8 10.3	4 9	12 20	21 6			
RW Capric.	12.2	—17 59	8.8—10.6	3 09.4	5 7	12 2	18 21	25 16		
UW Cygni	19.6	+42 55	10.5—13	3 10.8	7 7	14 5	21 2	28 1		
V Vulpec.	32.3	+26 15	8.2— 9.8	37 19.0				27 3		
W Delphini	33.1	+17 56	9.4—12.1	4 19.4	9 6	18 21	28 12			
RR Delphini	38.9	+13 35	10.5—11.8	4 14.4	8 2	17 6	26 12			
Y Cygni	48.1	+34 17	7.1— 7.9	1 12.0	7 5	16 5	25 4			
WZ Cygni	48.3	—38 27	9.9—10.8	0 14.0	6 11	14 1	21 15			
RR Vulpec.	20 50.5	+27 32	9.6—11.0	5 01.2	3 20	13 23	24 1			
RY Aquarii	14.8	—11 14	8.8—10.4	1 23.2	3 7	11 4	19 1	26 22		
RT Lacertæ	21 57.4	+43 24	9.1—10.5	5 01.7	1 3	11 6	21 10			
UZ Cygni	55.2	+43 52	8.9—11.6	31 07.3				25 1		
RW Lacertæ	22 40.6	+49 08	10.2—11.2	5 04.4	2 10	12 18	23 3	28 8		
VW Pegasi	51.7	+32 41	10.0—10.6	5 06.4	1 6	6 12	17 1	27 14		
Y Piscium	29.3	+ 7 22	9.0—12.0	3 18.3	7 3	14 16	22 4			
TW Androm.	23 58.2	+32 17	8.6—11.5	4 02.9	6 0	14 6	22 12			

Maxima of Variable Stars of Short Period.

[Calculated by members of the class in General Astronomy at Carleton College.]

Given to the nearest hour in Greenwich mean time; to obtain Eastern Standard time subtract 5^h; Central Standard time 6^h, etc.

Star	R.A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of maxima in 1923 February							
	h m	° ′		d h	d h	d h	d h	d h	d h	d h	d h	d h
SX Cassiop.	0 05.5	+54 20	8.6— 9.2	36 13.7			19 14					
SY Cassiop.	0 09.8	+57 52	9.3— 9.9	4 1.7	5 7		13 10		21 14			
RR Ceti	1 27.0	+ 0 50	8.3— 9.0	0 13.3	3 4		11 22		18 16		26 10	
RW Cassiop.	1 30.7	+57 15	8.9—11.0	14 19.2	5 3				19 22			
V Arietis	2 09.6	+11 46	8.3— 9.0	0 23.8	6 19		14 18		22 16			
SU Cassiop.	2 43.0	+68 28	6.5— 7.0	1 22.8	8 5		16 0		23 20			
RW Camelop.	3 46.2	+58 21	8.2— 9.4	16 00.0			15 21					
SX Persei	4 10.2	+41 27	10.4—11.2	4 07.0	5 21		14 11		23 1			
SV Persei	42.8	+42 07	8.8— 9.6	11 03.1	10 21		21 20					
RX Aurigæ	4 54.5	+39 49	7.2— 8.1	11 15.0	3 9		15 0		26 15			
SX Aurigæ	5 04.6	+42 02	8.0— 8.7	1 12.8	1 9		9 0		16 17		24 8	
SY Aurigæ	05.5	+42 41	8.4— 9.5	10 03.3	8 12		18 16		28 19			
Y Aurigæ	21.5	+42 21	8.6— 9.6	3 20.6	4 23		12 16		20 9		28 2	
RZ Gemin.	5 56.6	+22 15	9.1—10.0	5 12.7	4 16		10 5		21 6		26 19	
RS Orionis	6 16.5	+14 44	8.2— 8.9	7 13.6	6 17		14 6		21 20			
T Monoc.	19.8	+ 7 08	5.7— 6.8	27 00.3			12 6					
RT Aurigæ	23.0	+30 33	5.1— 6.0	3 17.5	7 23		15 10		22 21			
W Gemin.	29.2	+15 24	6.7— 7.5	7 22.0	3 6		11 4		19 2		27 0	
ζ Gemin.	6 58.2	+20 43	3.7— 4.3	10 03.7	1 10		11 14		21 17			
RU Camelop.	7 10.9	+69 51	8.5— 9.8	22 06.5	3 18				26 0			
RR Gemin.	7 15.2	+31 04	10.0—11.5	0 09.5	7 0		14 23		22 21			
V Carinæ	8 26.7	—59 47	7.4— 8.1	6 16.7	4 22		11 14		18 7		25 0	
T Velorum	8 34.4	—47 01	7.6— 8.5	4 15.3	5 20		15 3		24 10			
V Velorum	9 19.2	—55 32	7.5— 8.2	4 08.9	6 11		15 5		23 23			
Z Leonis	9 46.4	+27 22	7.9— 9.6	59 00.0					21 13			
RR Leonis	10 02.1	+24 29	9.1—10.1	0 10.9	5 1		11 20		18 14		25 9	
SU Draconis	11 32.2	+67 53	8.9— 9.6	0 15.8	1 23		8 13		21 18		28 8	
S Muscae	12 07.4	—69 36	6.4— 7.3	9 15.8	8 18		18 9		28 1			
SW Draconis	12.8	+70 04	8.8— 9.6	0 13.7	2 22		10 21		18 21		26 19	
T Crucis	15.9	—61 44	6.8— 7.6	6 17.6	6 1		12 18		19 12		26 6	
R Crucis	18.1	—61 04	6.8— 7.9	5 19.8	4 23		10 19		22 10		28 6	
S Crucis	12 48.4	—57 53	6.5— 7.6	4 16.6	3 16		13 1		22 10		27 3	
W Virginis	13 20.9	— 2 52	8.7—10.4	17 06.5			17 3					
SS Hydræ	25.0	—23 08	7.4— 8.1	8 04.8	4 0		12 5		20 10		28 15	
RV Urs. Maj.	13 29.4	+54 31	9.2— 9.9	0 11.2	6 1		13 2		20 2		27 3	
ST Virginis	14 22.5	— 0 27	10.3—11.4	0 09.9	2 0		10 6		18 12		26 17	
V Centauri	25.4	—56 27	6.4— 7.8	5 11.9	2 5		7 17		18 17		24 5	
RS Bootis	29.3	+32 11	8.9—10.0	0 09.1	7 16		15 5		22 18			
R Triang.Austr.	15 10.8	—66 08	6.7— 7.4	3 09.3	3 5		10 0		16 18		23 13	
S Triang.Austr.	15 52.2	—63 29	6.4— 7.4	6 07.8	1 3		7 10		20 2		26 9	
S Normæ	16 10.6	—57 39	6.6— 7.6	9 18.1	4 15		14 8		24 3			
RW Draconis	33.7	+58 03	9.6—10.8	0 10.6	1 19		15 16		24 13			
RV Scorpii	16 51.8	—33 27	6.7— 7.4	6 01.5	1 12		7 13		19 16		25 18	
X Sagittarii	17 41.3	—27 48	4.4— 5.0	7 00.3	4 4		11 4		18 4		25 5	
Y Ophiuchi	47.3	— 6 07	6.1— 6.5	17 02.9	1 7				18 10			
W Sagittarii	17 58.6	—29 35	4.3— 5.1	7 14.3	2 14		10 3		17 19		25 9	
Y Sagittarii	18 15.5	—18 54	5.4— 6.2	5 18.6	2 23		8 17		20 6		26 1	
U Sagittarii	26.0	—19 12	6.5— 7.3	6 17.9	2 20		9 14		16 7		23 1	
Y Scuti	32.6	— 8 27	8.7— 9.2	10 08.3	5 17		16 1		26 9			
RZ Lyræ	18 39.9	+32 42	9.9—11.2	0 12.3	5 15		11 19		17 22		24 1	
RT Scuti	18 44.1	—10 30	9.1— 9.7	0 11.9	5 17		11 16		17 14		23 13	
κ Pavonis	18 46.6	—67 22	3.8— 5.2	9 02.2	6 10		15 12		24 14			
U Aquilæ	19 24.0	— 7 15	6.2— 6.9	7 00.6	1 11		8 12		15 12		22 13	

Maxima of Variable Stars of Short Period—Continued.

Star	R.A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of maxima in 1923 February							
	h m	° ′		d h	d h	d h	d h	d h	d h	d h	d h	d h
XZ Cygni	30.4	+56 10	8.6— 9.3	0 11.2	4 21	11 21	18 21	25 21				
U Vulpec.	32.2	+20 07	6.5— 7.6	7 23.5	6 2	14 2	22 1					
SU Cygni	40.8	+29 01	6.2— 7.0	3 20.3	4 8	12 1	19 18	27 11				
η Aquilæ	47.4	+ 0 45	3.7— 4.5	7 04.2	2 5	9 10	16 14	23 18				
S Sagittæ	51.5	+16 22	5.6— 6.4	8 09.2	7 8	15 16	24 2					
X Vulpec.	19 53.3	+26 17	9.5—10.5	6 07.7	3 11	9 19	22 11	28 18				
X Cygni	20 39.5	+35 14	6.0— 7.0	16 09.3	11 21		28 6					
T Vulpec.	47.2	+27 52	5.5— 6.1	4 10.5	1 20	10 17	19 13	28 10				
WY Cygni	52.3	+30 03	9.6—10.4	0 13.5	5 12	12 6	18 23	25 17				
RV Capric.	55.9	—15 37	9.2—10.1	0 10.7	6 2	12 19	19 12	26 6				
TX Cygni	20 56.4	+42 12	8.5— 9.7	14 17.4	2 12		17 5					
VY Cygni	21 00.4	+39 34	8.8— 9.5	7 20.6	1 4	9 0	16 21	24 17				
SW Aquarii	10.2	— 0 20	9.9—10.8	0 11.0	6 4	13 1	19 23	26 20				
VZ Cygni	21 47.7	+42 40	8.2— 9.2	4 20.7	2 2	11 19	16 16	26 9				
Y Lacertæ	22 05.2	+50 33	9.1— 9.6	4 07.8	5 1	12 17	21 9					
δ Cephei	25.5	+57 54	3.7— 4.6	5 08.8	3 1	8 9	19 3	24 12				
Z Lacertæ	36.9	+56 18	8.2— 9.0	10 21.1	1 18	12 15	23 13					
RR Lacertæ	37.5	+55 55	8.5— 9.2	6 10.1	3 15	10 1	16 11	22 21				
V Lacertæ	44.5	+55 48	8.5— 9.5	4 23.6	3 2	13 1	18 1	23 0				
X Lacertæ	22 45.0	+55 54	8.2— 8.6	5 10.7	1 19	7 5	18 3	23 13				
SW Cassiop.	23 03.7	+58 11	9.2— 9.7	5 10.6	4 22	10 9	21 6	26 16				
πS Cassiop.	32.6	+61 52	9.0—11.0	6 07.1	2 4	8 11	21 1	27 8				
RY Cassiop.	47.2	+58 11	9.3—11.8	12 03.4	7 18	19 21						
V Cephei	23 51.7	+82 38	6.0— 7.0	0 23.9	7 7	14 7	21 6	28 6				

Monthly Report of the American Association of Variable Star Observers, October 20 to November 20, 1922.

All three irregular variables of the SS Cygni type have been active, SS Cygni itself undergoing one of its long, slow rising type maxima during October. U Geminorum a normal long type at about the same time, and SS Aurigæ a long normal type in November. The report as a whole is a good one, with many observers participating, Mr. Inglis and several of Mr. Leavenworth's students for the first time. Harvard College Observatory is well satisfied with the response for observations of Beta Lyræ and Beta Persei, which however will not be included in the monthly reports, but discussed at a later time.

Mrs. Helen A. Holmes of Bristol, R. I., and Mr. John C. Bergey of Sumneytown, Pa., have been recently elected to membership. Mr. G. C. Waldo lectured before the Rotary Club of Bridgeport recently.

The following observers contributed to this report: Ancarani "An" 3, Bemporad "Bp" 6, Bouton "B" 6, Brocchi "Br" 6, Miss Carlson "Cn", Carr "Ca" 3, Chandra "Ch" 3, Christie "Ct" 2, Clough "Cg" 3, Cohen "Ce", Ginori "Gi" 9, Godfrey "Gd" 8r, Hunter "Hu" 8, Inglis "I", Miss Jenkins "Jk" 3, Miss Johnson "Jh", Jordan "Jd" 6, Kanda "Kd" 2, Kraute "Kr", Lacchini "L" 5, Lacy "Lc" 4, Leavenworth "Lv" 10, McAteer "M" 5, Nakamura "Nk" 4 and 10, Olcott "O" 5, Dr. Paraskevopoulos "Jp" 16, Mrs. Paraskevopoulos "Dp" 16, Peltier "Pt" 6, de Perrot "Pe" 4, Proctor "Pc" 12, Rhorer "Ro", Skaggs "Sg" 5, Suter "Su"4, Waterfield "Wf" 12r, Yalden "Ya" 4, and Miss Young "Y" 8.

HOWARD O. EATON, Recording Secretary.

VARIABLE STAR OBSERVATIONS, October 20 to November 20, 1922.

October 0 = J. D. 2423328 November 0 = J. D. 2423359

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
001032 S SCULPTORIS—												
	3354.7	8.6	Pt.									
001046 X ANDROMEDAE—												
	3345.7	8.9	Wf,	3347.7	9.1	Lv,	3349.5	9.2	O,	3360.6	9.0	B,
	3378.6	9.0	Hu,	3378.6	9.7	M.						
001620 T CETI—												
	3264.2	5.7	Nk.	3323.0	6.4	Kd,	3336.0	6.5	Kd,	3339.0	6.7	Kd,
	3341.4	6.3	An,	3341.5	6.6	L,	3343.1	6.6	Kd,	3347.0	6.7	Kd.
	3350.0	6.5	Kd.									
001726 T ANDROMEDAE—												
	3280.2	9.2	Ch,	3296.2	9.1	Ch,	3305.1	8.8	Ch,	3329.7	9.5	Lv,
	3347.6	10.8	O,	3347.7	11.0	Lv,	3352.5	11.0	O,	3354.3	10.5	Pt,
	3356.7	11.5	Br,	3357.5	11.0	Gd,	3357.5	11.0	O,	3364.5	11.6	B,
	3372.5	12.0	O.									
001755 T CASSIOPEIAE—												
	3283.2	8.4	Ch,	3305.1	8.5	Ch,	3309.1	8.5	Nk,	3312.2	8.6	Ch,
	3341.3	11.2	L,	3354.7	10.3	Pt,	3364.5	9.7	B.			
001838 R ANDROMEDAE—												
	3342.7	14.6	Wf,	3354.7	14.5	Pt.						
001909 S CETI—												
	3311.2	11.3	Ch,	3344.3	9.9	L,	3347.8	9.5	Sg,	3354.7	9.1	Pt,
	3369.8	8.8	Sg.									
004047 U CASSIOPEIAE—												
	3345.7	12.0	Wf,	3348.7	12.3	Lv,	3349.5	12.0	O,	3352.7	11.1	Lc,
	3364.5	12.6	B.									
004132a RW ANDROMEDAE—												
	3347.6	10.8	O,	3347.7	10.4	Wf,	3352.5	10.9	O,	3356.7	10.7	Br.
004435 V ANDROMEDAE—												
	3347.6	12.4	O,	3348.7	11.7	Lv,	3352.5	11.4	O,	3356.7	11.2	Br.
	3372.5	10.8	O,	3378.6	10.0	Hu.						
004533 RR ANDROMEDAE—												
	3347.6	11.6	O,	3347.7	11.1	Wf,	3352.5	11.1	O,	3356.7	10.9	Br,
	3364.6	10.7	B,	3372.5	10.3	O,	3378.6	10.2	Hu.			
004746a RV CASSIOPAE—												
	3345.7	14.5	Wf.									
004958 W CASSIOPEIAE—												
	3340.6	11.1	Gi,	3349.5	11.8	O,	3356.7	11.1	Br,	3360.6	10.6	B.
010102 Z CETI—												
	3373.6	9.2	B.									
010940 U ANDROMEDAE—												
	3345.7	13.4	Wf,	3373.6	13.7	B.						
011041 UZ ANDROMEDAE—												
	3345.7	<14.2	Wf.									
011208 S PISCIUM—												
	3372.6	12.0	Y.									
011272 S CASSIOPEIAE—												
	3341.7	14.3	Wf.									
011712 U PISCIUM—												
	3356.8	12.2	Br.									
012350 RZ PERSEI—												
	3372.6	12.5	Y,	3373.6	13.1	B.						
012502 R PISCIUM—												
	3348.6	12.7	Y,	3372.6	13.3	Y.						
013238 RU ANDROMEDAE—												
	3345.7	10.6	Wf.	3360.6	10.4	B,	3378.6	11.0	Hu.			
014958 X CASSIOPEIAE—												
	3365.5	12.6	O,	3372.6	12.3	Y.						
015354 U PERSEI—												
	3347.6	9.5	O,	3349.7	9.6	Sg.						

VARIABLE STAR OBSERVATIONS, October 20 to November 20, 1922—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
021024 R ARIETIS—												
	3311.2	10.3	Ch,	3329.6	10.4	L,	3341.5	8.9	Gi.	3347.6	8.5	O.
	3347.6	8.7	M,	3351.6	8.2	Ct,	3355.5	8.5	Ca,	3358.7	8.0	Ct,
	3361.5	8.0	O,	3367.8	8.6	Ct.	3368.5	8.1	O.	3369.7	8.5	Ct.
	3370.6	8.5	Ct,	3370.7	8.5	Br,	3371.5	8.0	Ca,	3376.6	8.5	Ct.
021143a W ANDROMEDAE—												
	3293.2	9.3	Ch,	3305.3	8.5	Ch,	3309.0	7.7	Nk.	3310.0	8.0	Nk,
	3311.2	8.5	Ch,	3345.3	7.4	Gi,	3345.7	7.4	Wf,	3347.6	8.7	M.
	3365.6	7.8	B,	3378.6	8.2	Hu.						
021281 Z CEPHEI—												
	3341.7	<14.0	Wf.									
021403 o CETI—												
	3258.3	6.2	Nk,	3297.4	7.7	Ch,	3311.2	8.2	Ch,	3341.4	8.7	An,
	3344.4	8.5	L,	3345.4	8.9	An,	3347.6	8.8	M,	3354.7	8.4	Pt,
	3355.5	8.5	Ca,	3358.5	8.5	O,	3369.8	8.2	Sg.	3372.5	8.5	Ca,
	3372.5	8.3	O.									
021558 S PERSEI—												
	3354.7	10.0	Pt,	3370.7	10.5	Br,	3373.6	10.5	B.			
022000 R CETI—												
	3355.5	8.1	Ca,	3372.5	8.1	Ca.						
022150 RR PERSEI—												
	3341.7	14.5	Wf,	3372.6	<13.5	Y.						
022813 U CETI—												
	3297.4	11.2	Ch,	3354.7	7.4	Pt,	3370.7	7.8	Br,	3372.6	7.7	Y.
	3373.6	7.3	B.									
022980 RR CEPHEI—												
	3329.6	12.8	L,	3341.7	13.2	Wf.						
023133 R TRIANGULI—												
	3341.0	7.0	Kd.	3343.0	7.0	Kd.	3344.1	7.0	Kd,	3347.6	7.1	O,
	3349.0	7.1	Kd,	3352.1	7.1	Kd,	3354.7	7.2	Pt,	3368.5	7.0	O,
	3370.7	7.2	Br,	3376.6	7.7	Ya,	3377.8	8.0	M.	3378.6	8.0	Hu.
024217 T ARIETIS—												
	3258.3	9.3	Nk.									
024356 W PERSEI—												
	3257.2	10.0	Nk,	3258.3	10.2	Nk,	3263.1	9.8	Nk,	3267.1	9.8	Nk,
	3299.0	10.1	Nk,	3309.0	9.9	Nk,	3310.0	9.9	Nk,	3312.1	10.0	Nk,
	3349.5	10.5	Br,	3354.7	10.5	Ca,	3359.5	10.1	Ca,	3361.5	10.3	O,
	3370.7	10.5	Br,	3371.5	10.4	Ca,	3372.5	10.5	O,	3373.6	10.1	B,
	3376.6	10.4	Ya,	3377.8	10.5	M,	3378.6	10.0	Hu.			
030514 U ARIETIS—												
	3372.6	<13.0	Y.									
031401 X CETI—												
	3345.7	11.5	Wf.	3354.7	11.8	Pt.						
032043 Y PERSEI—												
	3347.6	10.3	O,	3354.7	9.7	Pt,	3377.8	10.2	M,	3378.6	9.5	Hu.
032335 R PERSEI—												
	3341.5	9.3	Gi.	3354.7	9.5	Pt,	3377.8	12.4	M.			
041619 T TAURI—												
	3377.8	10.0	M.									
042215 W TAURI—												
	3347.7	10.6	M,	3353.8	10.5	Sg,	3369.8	10.9	Sg,	3370.7	10.7	Br,
	3372.5	10.8	O,	3375.7	11.0	Pt,	3377.9	10.5	M.	3378.6	11.0	Hu.
043065 T CAMELOPARDALIS—												
	3341.3	11.5	L,	3375.7	12.6	Pt,	3377.8	12.2	M.			
043274 X CAMELOPARDALIS—												
	3370.7	8.0	Br,	3375.7	8.0	Pt,	3377.8	8.3	M.			
044617 V TAURI—												
	3341.7	12.9	Wf,	3345.9	12.6	Wf,	3375.7	10.7	Pt.			
045307 R ORIONIS—												
	3344.6	10.4	Gi,	3348.7	11.1	Y,	3372.6	11.3	Y.	3377.8	11.8	M.

VARIABLE STAR OBSERVATIONS, October 20 to November 20, 1922—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
045514 R LEPORIS—												
	3296.4	7.9	Ch,	3314.4	7.9	Ch,	3358.7	7.9	Ca,	3370.8	8.8	Ct,
	3375.7	8.0	Pt,	3377.8	8.6	M.						
050003 V ORIONIS—												
	3348.7	10.0	Y,	3373.6	10.8	Y,	3375.7	11.5	Pt,	3377.8	11.5	M.
050022 T LEPORIS—												
	3375.7	11.4	Pt.									
050953 R AURIGAE—												
	3352.7	8.3	Lc,	3370.7	7.5	Br,	3375.7	7.3	Pt,	3378.6	7.7	M.
052034 S AURIGAE—												
	3375.7	8.5	Pt.									
052404 S ORIONIS—												
	3352.8	8.4	M,	3371.7	9.3	Ca,	3375.7	9.2	Pt,	3377.8	9.5	M.
053005a T ORIONIS—												
	3329.6	10.1	L,	3349.8	10.4	Pt,	3352.8	10.3	M,	3354.7	10.0	Pt,
	3356.9	10.0	Pt,	3375.7	10.6	Pt,	3377.8	10.2	M.			
053068 S CAMELOPARDALIS—												
	3375.7	8.5	Pt.									
053531 U AURIGAE—												
	3348.7	12.8	Y,	3372.5	13.0	Y,	3375.7	12.8	Pt.			
054319 SU TAURI—												
	3296.4	10.0	Ch,	3329.6	9.5	L,	3333.4	9.4	Jp,	3333.4	9.5	Dp,
	3341.7	9.4	Wf,	3345.4	9.4	Jp,	3345.4	9.4	Dp,	3345.9	9.4	Wf,
	3348.7	9.5	Y,	3349.8	9.5	Pt,	3354.7	9.5	Pt,	3355.8	9.5	Pt,
	3356.9	9.6	Pt,	3357.8	9.6	Pt,	3370.8	9.6	Br,	3375.7	9.6	Pt,
	3377.9	9.5	M.									
054920a U ORIONIS—												
	3296.4	6.0	Ch,	3355.7	8.6	Ct,	3359.8	8.6	Ct,	3368.6	8.5	Ca,
	3368.7	8.8	Ct,	3369.7	8.7	Ct,	3370.8	8.8	Ct,	3375.7	8.7	Pt.
	3377.9	8.6	M.									
054974 V CAMELOPARDALIS—												
	3369.7<13.5 Wf.											
055353 Z AURIGAE—												
	3345.7	10.6	Wf,	3375.7	9.5	Pt.	3377.9	9.3	M.			
060450 X AURIGAE—												
	3370.8	12.5	Br,	3375.7	12.5	Pt.						
060547 SS AURIGAE—												
	3296.4<12.4		Ch,	3329.6	13.6	L,	3330.4<12.4		Jp,	3330.4<12.4		Dp,
	3333.4<12.4		Jp,	3333.4<12.4		Dp,	3340.6<13.8		Gi,	3340.7<13.9		Wf,
	3341.5<13.8		Gi,	3341.7<13.9		Wf,	3342.8<12.4		Br,	3344.6<13.9		Gi,
	3344.7<13.9		Wf,	3345.4<13.3		Jp,	3345.4<13.3		Dp,	3345.9<14.5		Wf,
	3348.6<13.3		Y,	3348.7<12.6		Pt,	3349.8<12.6		Pt,	3352.8<12.4		M,
	3354.7<12.6		Pt,	3355.8<12.6		Pt,	3356.9<12.6		Pt,	3357.8	13.5	Pt,
	3365.5	11.1	Pt,	3366.5	10.9	Pt,	3368.5	11.0	O,	3369.6	10.9	Pt,
	3369.7	10.8	Wf,	3370.7	10.8	Wf,	3370.7	10.8	Br,	3372.5	10.8	O,
	3372.6	10.8	Y,	3374.6	11.0	Y,	3375.5	11.7	O,	3375.7	12.0	Pt,
061702 V MONOCEROTIS—												
	3349.8	11.6	Pt.									
063159 U LYNCIS—												
	3348.5	9.9	O,	3372.5	9.9	O.						
063308 R MONOCEROTIS—												
	3349.8	10.8	Pt.									
063558 S LYNCIS—												
	3348.5	11.9	O,	3349.9	12.0	Pt.						
064030 X GEMINORUM—												
	3344.6	12.6	Gi.									
064707 W MONOCEROTIS—												
	3349.9	11.1	Pt.									
065111 Y MONOCEROTIS—												
	3349.9	8.8	Pt.									

VARIABLE STAR OBSERVATIONS, October 20 to November 20, 1922—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
065355 R LYNCIS—												
	3341.8	11.4	Wf.									
070109 V CANIS MINORIS—												
	3352.8	9.4	M.									
070122a R GEMINORUM—												
	3296.4	11.3	Ch,	3349.9	6.4	Pt.	3352.8	6.5	M.	3371.7	7.0	Ca.
070122b Z GEMINORUM—												
	3349.9	12.7	Pt.									
070122c TW GEMINORUM—												
	3352.8	8.8	M.	3371.7	8.2	Ca.						
071713 V GEMINORUM—												
	3349.9	13.8	Pt.									
072708 S CANIS MINORIS—												
	3349.9	12.0	Pt.	3352.8	12.0	M.						
072811 T CANIS MINORIS—												
	3349.9	11.9	Pt.	3352.8	12.4	M.						
073508 U CANIS MINORIS—												
	3349.9	8.9	Pt,	3352.8	9.3	M.						
073723 S GEMINORUM—												
	3349.9	8.4	Pt,	3352.8	8.6	M.						
074323 T GEMINORUM—												
	3349.9	8.8	Pt.	3352.8	8.8	M.						
074922 U GEMINORUM—												
	3329.6	13.9	L,	3340.6	<12.8	Gi.	3343.9	9.5	Wf.	3344.6	9.7	Gi,
	3345.9	9.3	Wf,	3349.8	9.7	Pt.	3352.8	10.2	M.	3354.7	11.6	Pt,
	3355.8	12.5	Pt,	3356.8	13.0	Pt,	3357.8	<13.3	Pt.	3375.7	<13.3	Pt.
081112 R CANCRI—												
	3349.9	11.0	Pt,	3352.9	10.8	M.						
081617 V CANCRI—												
	3349.9	8.2	Pt.	3352.9	7.6	M.						
082405 RT HYDRAE—												
	3329.7	7.8	L,	3349.9	6.9	Pt.						
083019 U CANCRI—												
	3343.9	<13.3	Wf.									
083350 X URSAE MAJORIS—												
	3349.9	11.9	Pt.									
084803 S HYDRAE—												
	3349.9	10.9	Pt.									
085008 T HYDRAE—												
	3349.9	12.0	Pt.									
085120 T CANCRI—												
	3349.9	8.3	Pt.									
090024 S PYXIDIS—												
	3349.9	9.6	Pt.									
090425 W CANCRI—												
	3329.6	12.8	L,	3343.9	13.5	Wf.						
093014 X HYDRAE—												
	3356.9	9.0	Pt.									
093178 Y DRACONIS—												
	3349.3	10.4	Jp.	3349.3	10.3	Dp.						
093934 R LEONIS MINORIS—												
	3356.9	12.3	Pt.									
094211 R LEONIS—												
	3356.9	6.0	Pt.	3371.7	6.3	Ca.						
094622 Y HYDRAE—												
	3356.9	6.5	Pt.									
095421 V LEONIS—												
	3356.9	10.7	Pt.									

VARIABLE STAR OBSERVATIONS, October 20 to November 20, 1922—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
103769 R URSAE MAJORIS—												
	3307.1	8.4	Ch,	3325.3	9.7	Jp,	3325.3	9.5	Dp,	3346.2	10.3	Jp,
	3346.2	10.3	Dp,	3348.5	11.2	Pt,	3350.7	11.0	Sg.	3370.8	11.8	Br.
104630 V HYDRAE—												
	3356.9	9.3	Pt.									
110506 S LEONIS—												
	3356.9	12.5	Pt.									
120012 SU VIRGINIS—												
	3356.9	11.9	Pt.									
122532 T CANUM VENATICORUM—												
	3221.0	10.5	Jk,	3248.0	11.3	Nk,	3256.0	10.6	Nk,	3257.0	10.5	Nk,
	3267.0	10.3	Nk,	3356.9	9.6	Pt,	3377.9	10.2	M.			
123160 T URSAE MAJORIS—												
	3263.1	9.6	Ch,	3282.1	8.1	Ch,	3297.1	8.0	Ch,	3306.6	7.6	Jd,
	3307.1	8.0	Ch,	3344.7	8.5	Sg,	3348.5	9.0	O,	3349.6	8.8	Pc,
	3356.9	9.3	Pt,	3368.5	10.0	Ca,	3377.5	11.0	Cg.			
123307 R VIRGINIS—												
	3247.0	8.6	Nk,	3267.0	10.7	Nk,	3287.1	11.0	Ch,	3337.2	8.4	Jp,
	3337.2	8.4	Dp,	3346.2	8.6	Jp,	3346.2	8.6	Dp,	3356.9	7.2	Pt.
123459 RS URSAE MAJORIS—												
	3219.0	9.1	Jk,	3263.1	11.0	Ch,	3343.7	14.0	Wf,	3365.7	14.2	Wf.
123961 S URSAE MAJORIS—												
	3281.1	9.3	Ch,	3297.1	8.9	Ch,	3306.6	9.0	Jd,	3307.1	8.6	Ch,
	3337.2	8.2	Jp,	3337.2	8.1	Dp,	3344.3	7.9	Jp,	3344.7	7.7	Dp,
	3346.2	7.9	Jp,	3346.2	7.9	Dp,	3348.5	8.1	O,	3349.6	8.0	Pc,
	3350.5	8.0	Jd,	3352.9	8.3	M,	3356.6	7.9	Ct,	3356.9	7.7	Pt,
	3359.5	7.0	Jd,	3360.7	7.7	Ct,	3361.7	7.7	Ct,	3367.6	7.5	Ct,
	3368.5	7.4	Ca,	3368.6	7.5	Ct,	3370.6	7.6	Ct,	3371.6	7.6	Ct,
	3377.5	8.3	Cg,	3377.8	8.0	M.						
133273 T URSAE MINORIS—												
	3343.7	12.1	Wf,	3349.3	11.8	Jp,	3349.3	11.8	Dp,	3369.7	12.8	Wf.
134440 R CANUM VENATICORUM—												
	3219.0	9.4	Jk,	3356.9	11.5	Pt.						
141567 U URSAE MINORIS—												
	3282.1	11.4	Ch,	3307.1	11.8	Ch,	3341.6	11.1	Lv,	3349.3	12.4	Jp,
	3349.3	12.2	Dp.									
141954 S BOOTIS—												
	3279.1	8.2	Ch,	3296.1	8.9	Ch,	3306.1	9.3	Ch,	3311.1	9.8	Ch,
	3345.3	11.3	L,	3348.5	11.2	Pt.						
142539 V BOOTIS—												
	3282.2	10.9	Ch,	3305.1	10.6	Ch,	3306.8	9.8	Jd,	3345.3	9.0	L,
	3348.5	8.5	Pt,	3349.7	8.5	Sg.	3355.5	8.4	Ca.	3372.4	7.8	Ca.
142584 R CAMELOPARDALIS—												
	3292.1	10.9	Ch,	3325.3	12.7	Jp,	3325.3	12.6	Dp,	3343.7	13.9	Wf,
	3348.5	13.0	Pt,	3369.7	13.6	Wf.						
143227 R BOOTIS—												
	3263.2	7.4	Ch,	3279.1	7.2	Ch,	3289.1	7.4	Ch,	3297.1	7.8	Ch,
	3301.1	7.9	Ch,	3310.1	8.5	Ch,	3348.5	10.3	Pt.			
151520 S LIBRAE—												
	3280.1	10.8	Ch,	3307.1	9.4	Ch.						
151714 S SERPENTIS—												
	3344.6	10.7	Wf,	3345.2	10.5	L.						
151731 S CORONAE BOREALIS—												
	3247.0	12.5	Nk,	3257.0	13.1	Nk,	3267.1	13.0	Nk,	3301.6	11.1	Jd,
	3310.9	12.1	Nk,	3322.0	12.1	Nk,	3343.7	11.6	Wf,	3348.5	11.0	M,
	3348.5	11.2	Pt,	3349.7	11.6	Sg,	3370.6	8.9	Wf.			
152714 RU LIBRAE—												
	3229.0	8.8	Nk,	3257.0	9.2	Nk,	3263.2	9.7	Nk,	3267.1	10.1	Nk.

VARIABLE STAR OBSERVATIONS, October 20 to November 20, 1922—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
153378 S URSAE MINORIS—												
	3248.1	8.2	Nk,	3250.1	8.6	Nk,	3252.1	8.5	Nk,	3256.0	8.3	Nk,
	3257.1	8.5	Nk,	3259.0	8.5	Nk,	3260.1	8.6	Nk,	3262.1	8.5	Nk,
	3267.1	8.6	Nk,	3299.0	9.2	Nk,	3310.9	10.1	Nk,	3322.0	10.0	Nk,
	3342.6	10.0	Br,	3343.7	10.0	Wf,	3347.8	10.6	Sg,	3349.3	9.7	Jp.
	3349.3	9.6	Dp,	3368.5	10.9	Ca,	3372.7	11.0	Sg.			
154428 R CORONAE BOREALIS—												
	3241.1	6.2	Nk,	3242.0	6.4	Nk,	3247.0	6.0	Nk,	3248.1	6.2	Nk,
	3249.0	6.2	Nk,	3251.1	6.2	Nk,	3252.1	6.0	Nk,	3255.0	6.4	Nk,
	3257.0	6.5	Nk,	3259.0	6.5	Nk,	3260.0	6.6	Nk,	3262.0	6.6	Nk,
	3263.0	6.5	Nk,	3264.0	6.6	Nk,	3267.0	6.9	Nk,	3267.2	7.0	Nk,
	3274.2	6.2	Ch,	3299.0	5.9	Nk,	3306.6	6.6	Jd,	3307.1	6.1	Ch,
	3308.0	6.0	Nk,	3311.0	5.9	Nk,	3321.9	6.1	Kd,	3322.0	6.0	Nk,
	3335.9	5.9	Kd,	3337.7	6.3	Br,	3337.9	6.0	Kd,	3340.7	6.3	Wf,
	3341.3	6.2	An,	3341.3	6.1	L,	3341.5	6.3	I,	3341.6	6.2	Wf,
	3342.9	5.9	Kd,	3343.7	6.2	Wf,	3344.3	6.2	L,	3344.6	6.1	Wf,
	3344.7	6.0	Sg,	3345.3	6.2	An,	3346.5	6.3	I,	3348.5	6.5	M,
	3348.5	6.2	O,	3348.5	6.3	Pt,	3349.5	6.2	Pt,	3349.9	6.0	Kd,
	3349.7	6.0	Sg,	3351.5	6.1	I,	3351.5	6.1	Pt,	3352.5	6.1	Pt,
	3352.7	6.0	Sg,	3353.5	6.2	Pt,	3354.5	6.2	Pt,	3355.5	6.2	Pt,
	3355.5	6.1	Ca,	3356.5	5.8	I,	3356.5	6.2	Pt.	3356.6	6.4	Ct,
	3357.5	6.1	Pt,	3358.2	6.3	An,	3358.5	6.1	Pt,	3359.5	6.1	Pt,
	3359.6	6.4	Ct,	3363.5	6.2	Pt,	3363.6	6.5	Ct,	3365.5	6.2	Pt,
	3366.5	6.2	Pt.	3367.7	6.4	Ct,	3368.6	6.6	Ct.	3369.5	6.1	Pt,
	3369.6	6.4	Wf,	3370.6	6.2	Wf,	3370.6	6.7	Ct.	3371.5	6.4	I,
	3372.5	6.0	Ca,	3372.5	6.8	Jd,	3375.5	6.3	Pt,	3376.6	6.8	Ct,
	3377.5	6.5	Cg.									
154536 X CORONAE BOREALIS—												
	3343.7	13.2	Wf,	3370.6	12.6	Wf.						
154639 V CORONAE BOREALIS—												
	3343.7	7.6	Wf,	3348.5	7.0	Wf,	3348.5	7.3	M,	3370.6	7.6	Wf.
	3372.5	7.4	Ca.									
154715 R LIBRAE—												
	3257.0	10.4	Nk,	3259.0	10.3	Nk,	3267.0	10.3	Nk.			
155018 RR LIBRAE—												
	3280.1	9.1	Ch,	3293.1	10.5	Ch,	3306.1	11.4	Ch.			
160210 U SERPENTIS—												
	3247.0	11.5	Nk,	3259.0	10.5	Nk.	3260.0	10.4	Nk,	3262.0	10.4	Nk,
	3263.1	10.2	Nk,	3267.0	9.3	Nk.	3310.9	9.2	Nk,	3322.9	9.5	Nk,
	3348.5	10.3	Pt.									
160625a RU HERCULIS—												
	3341.6	12.0	Wf,	3345.3	12.6	L,	3348.5	11.9	Pt,	3370.6	11.6	Wf.
160625b SX HERCULIS—												
	3342.3	7.8	L.	3348.5	8.1	Pt.	3349.6	12.4	Pc,	3353.5	8.2	Pt,
	3355.5	8.1	Pt,	3357.5	8.2	Pt,	3359.5	8.2	Pt,	3365.5	8.6	Pt,
	3369.5	8.7	Pt,	3375.5	9.4	Pt.						
161138 W CORONAE BOREALIS—												
	3341.6	13.3	Wf,	3348.5	13.3	Pt,	3370.6	13.0	Wf.			
162112 V OPHIUCHI—												
	3283.2	8.4	Ch,	3293.2	8.1	Ch.	3312.1	7.9	Ch.	3348.5	7.7	Pt.
162119 U HERCULIS—												
	3343.7	12.8	Wf.	3348.5	13.2	Pt,	3370.6	12.1	Wf.			
162807 SS HERCULIS—												
	3335.2	9.7	Jp.	3335.2	9.8	Dp,	3345.3	10.3	L,	3347.2	10.3	Jp,
	3347.2	10.4	Dp,	3348.5	10.5	Pt.						
163137 W HERCULIS—												
	3348.5	13.0	Pt,	3348.5	13.0	B.						
163266 R DRACONIS—												
	3310.1	<12.0	Ch,	3315.2	12.3	Ch,	3348.5	10.4	Pt,	3349.3	10.4	Jp,
	3349.3	10.4	Dp.	3356.6	10.0	Br,	3358.5	9.5	Ya,	3371.5	7.9	Ca,
	3372.6	8.2	Jd.									

VARIABLE STAR OBSERVATIONS, October 20 to November 20, 1922—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
164055 S DRACONIS—												
	3348.5	8.2	M.									
164319 RR OPHIUCHI—												
	3348.5	10.7	Pt.									
164715 S HERCULIS—												
	3292.2	10.4	Ch.	3308.1	9.4	Ch.	3342.3	7.9	Gi.	3348.5	8.0	Pt.
	3350.5	8.5	Gd.	3355.5	7.1	Ca.	3372.5	7.3	Ca.			
165631 RV HERCULIS—												
	3341.6<	13.4	Lv.	3350.6<	12.4	Gd.	3352.5	12.5	B.	3364.5	12.1	M.
170215 R OPHIUCHI—												
	3312.2	11.7	Ch.	3348.5	8.5	Pt.						
170627 RT HERCULIS—												
	3343.7	8.5	Wf.	3348.5	8.7	O.	3350.5	8.7	Gd.	3352.6	8.8	Ya.
	3365.5	8.7	Pt.	3369.5	9.0	B.	3370.6	9.0	Wf.			
171401 Z OPHIUCHI—												
	3325.3	11.6	Jp.	3325.3	11.6	Dp.	3347.2	10.4	Jp.	3347.2	10.2	Dp.
	3348.6	11.2	Pt.	3349.3	10.8	Gi.	3372.5	9.2	Ca.			
171723 RS HERCULIS—												
	3241.1	10.5	Nk.	3242.2	10.4	Nk.	3245.1	11.2	Nk.	3248.0	11.1	Nk.
	3256.1	11.1	Nk.	3257.0	11.1	Nk.	3259.0	11.1	Nk.	3267.0	11.4	Nk.
	3311.0	12.3	Nk.	3320.0	12.1	Nk.	3335.2	10.4	Jp.	3335.2	10.5	Dp.
	3343.7	9.6	Wf.	3347.2	9.6	Jp.	3347.2	9.7	Dp.	3348.6	9.6	Pt.
	3350.5	9.6	Gd.	3352.6	9.4	B.	3370.6	8.9	Wf.			
172809 RU OPHIUCHI—												
	3337.2	12.9	Jp.	3337.2	13.0	Dp.	3347.3	12.9	Jp.	3347.3	13.0	Dp.
	3348.6	13.8	Pt.									
173212 RT SERPENTIS—												
	3345.3	9.4	L.									
174106 RS OPHIUCHI—												
	3365.5	11.0	Pt.									
175111 RT OPHIUCHI—												
	3337.2<	12.7	Dp.	3352.5	12.8	B.						
175458a T DRACONIS—												
	3279.1	10.2	Ch.	3293.1	10.3	Ch.	3306.1	10.3	Ch.	3349.3	10.7	Jp.
	3349.3	10.8	Dp.	3356.6	11.0	Br.						
175458b UY DRACONIS—												
	3279.1	10.2	Ch.	3295.1	10.3	Ch.	3314.1	10.3	Ch.	3349.3	11.6	Jp.
	3349.3	11.5	Dp.	3356.6	11.5	Br.						
175519 RY HERCULIS—												
	3283.2	9.8	Ch.	3308.1	9.4	Ch.	3334.3	9.2	Jp.	3334.3	9.3	Dp.
	3341.6	9.6	Lv.	3348.5	9.5	O.	3350.5	9.7	Gd.	3365.5	11.2	Pt.
	3366.5	10.6	B.									
175654 V DRACONIS—												
	3325.3	9.9	Jp.	3325.3	9.7	Dp.	3349.4	10.6	Jp.	3349.4	10.7	Dp.
	3350.5	11.3	O.									
180531 T HERCULIS—												
	3308.2	10.9	Ch.	3334.3	9.0	Jp.	3334.3	9.1	Dp.	3341.3	8.3	L.
	3346.7	8.0	Sg.	3349.4	7.9	Jp.	3349.4	7.9	Dp.	3350.5	8.4	O.
	3350.5	8.3	Gd.	3351.6	8.1	Ct.	3352.6	8.0	Gd.	3355.5	7.7	Ca.
	3356.6	7.8	Ct.	3359.6	7.6	Ct.	3365.5	7.6	Pt.	3366.6	7.6	O.
	3367.6	8.0	Ct.	3368.5	7.6	Ca.	3368.6	7.9	Ct.	3369.7	7.7	Ct.
	3370.6	7.8	Ct.	3370.7	7.6	Sg.	3371.6	8.0	Ct.	3372.6	8.1	Ct.
	3375.5	8.2	Gd.	3376.6	8.2	Ct.						
180565 W DRACONIS—												
	3341.6<	13.3	Lv.	3365.5	14.5	Pt.						
180666 X DRACONIS—												
	3341.6	11.7	Lv.	3349.4	11.9	Jp.	3349.4	11.8	Dp.	3356.6	11.7	Br.
	3365.5	11.7	Pt.									
180911 NOVA OPHIUCHI #4—												
	3341.3	12.2	L.	3366.6	13.2	Pt.						

VARIABLE STAR OBSERVATIONS, October 20 to November 20, 1922—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
181031 TV HERCULIS—												
	3341.3	9.6	L.									
181103 RY OPHIUCHI—												
	3341.6	12.1	Lv.	3342.3	12.0	Gi,	3342.3	12.2	Wf,	3360.6	10.0	Wf.
	3366.5	9.2	Pt,	3366.5	9.2	B,	3369.6	9.1	Wf.			
181136 W LYRAE—												
	3319.0	10.0	Jk.	3342.7	12.1	Wf,	3344.4	11.8	L.	3349.6	12.1	Pc,
	3360.6	12.3	Wf.	3366.5	12.1	Pt,	3366.5	12.2	B,	3369.6	12.1	Wf.
182224 SV HERCULIS—												
	3345.3	<13.6	L.									
182306 T SERPENTIS—												
	3366.5	13.0	Pt.									
183149 SV DRACONIS—												
	3325.4	12.7	Jp.	3325.4	12.6	Dp.						
183308 X OPHIUCHI—												
	3241.1	8.3	Nk,	3247.0	8.2	Nk,	3248.0	8.2	Nk,	3252.1	8.6	Nk,
	3257.0	8.2	Nk,	3259.1	8.0	Nk,	3262.1	8.3	Nk,	3267.1	8.3	Nk,
	3292.2	8.5	Ch.	3299.0	8.5	Nk,	3308.2	8.6	Ch.	3309.1	8.3	Nk,
	3342.3	8.6	L,	3355.6	8.7	B,	3366.5	8.4	Pt.			
184205 R SCUTI—												
	3241.1	5.6	Nk,	3242.0	5.5	Nk,	3247.0	5.7	Nk,	3252.1	5.6	Nk,
	3260.1	5.6	Nk,	3262.0	5.7	Nk,	3263.1	5.7	Nk,	3267.1	5.7	Nk,
	3289.2	5.9	Ch,	3299.0	6.0	Nk,	3307.1	6.9	Ch,	3309.0	6.3	Nk,
	3311.0	6.3	Nk,	3313.1	6.4	Nk,	3314.0	6.8	Nk,	3321.9	6.6	Kd,
	3322.9	6.6	Kd,	3335.9	5.9	Kd,	3337.7	5.9	Br,	3337.9	5.8	Kd,
	3340.9	5.8	Kd,	3341.3	6.0	An,	3341.3	5.8	L,	3342.9	5.9	Kd,
	3344.7	5.8	Sg,	3345.3	5.8	An,	3347.6	5.7	O,	3348.0	5.8	Kd,
	3348.5	5.5	Pt,	3349.5	5.7	Pt,	3349.7	5.5	Sg,	3349.9	5.4	Kd,
	3351.5	5.5	Pt,	3351.6	5.3	Ct,	3352.5	5.5	Ya,	3352.5	5.5	Pt,
	3353.5	5.4	Pt,	3354.5	5.2	Pt,	3355.3	5.4	Ro,	3355.5	5.2	Pt,
	3355.6	5.2	Ct,	3356.5	5.0	Pt,	3356.6	5.1	Ct,	3357.5	5.0	Pt,
	3358.2	5.5	An,	3358.5	5.0	Pt,	3359.5	5.0	Pt,	3359.6	5.2	Ct,
	3360.7	5.3	Ct,	3361.6	5.4	Ct,	3363.5	5.0	Pt,	3363.6	5.3	Ct,
	3365.5	5.3	Pt,	3366.5	5.3	Pt,	3367.5	5.2	Ro,	3367.6	5.2	Ct,
	3368.6	5.0	Ct,	3369.5	5.3	Pt,	3369.7	5.5	Ct,	3370.6	5.4	Ct,
	3371.6	5.3	Ct,	3375.5	5.8	Pt,	3376.5	5.8	Pt,	3376.6	5.6	Ct.
184208 S SCUTI—												
	3209.1	7.0	Nk,	3211.0	7.1	Nk,	3241.1	7.2	Nk,	3242.1	7.2	Nk,
	3247.0	7.2	Nk,	3248.0	7.1	Nk,	3252.1	7.5	Nk,	3257.0	7.2	Nk,
	3259.1	7.1	Nk,	3260.1	7.3	Nk,	3262.1	7.3	Nk,	3263.1	7.5	Nk,
	3267.0	7.1	Nk.									
184243 RW LYRAE—												
	3352.5	11.7	B,	3366.5	11.8	Pt.						
184300 NOVA AQUILAE #3—												
	3292.2	10.0	Ch,	3309.1	10.1	Nk,	3311.0	10.2	Nk,	3312.2	9.9	Ch,
	3344.3	10.2	L,	3344.7	10.1	Sg,	3350.3	10.2	Ro,	3353.5	9.8	Pt,
	3355.3	10.2	Ro,	3365.5	10.0	Pt,	3367.3	10.2	Ro,	3372.5	10.0	Ca,
	3375.5	10.2	Pt,	3378.5	9.8	Gd.						
185513a ST SAGITTARII—												
	3341.3	<13.0	L.									
185634 Z LYRAE—												
	3345.3	11.4	L,	3349.6	13.0	B,	3350.5	11.5	O.			
185737 RT LYRAE—												
	3325.4	<13.0	Dp,	3345.3	<13.0	Dp.						
185905 V AQUILAE—												
	3241.1	7.9	Nk,	3242.1	8.0	Nk,	3247.0	7.6	Nk,	3248.0	7.7	Nk,
	3250.0	7.9	Nk,	3252.1	7.9	Nk,	3257.0	7.3	Nk,	3259.1	7.3	Nk,
	3260.1	7.7	Nk,	3262.1	7.8	Nk,	3263.1	7.8	Nk,	3267.1	7.3	Nk,
	3299.0	7.4	Nk,	3309.1	7.5	Nk,	3311.0	7.7	Nk.			

VARIABLE STAR OBSERVATIONS, October 20 to November 20, 1922—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
190108 R AQUILAE—												
	3292.2	8.8	Ch,	3308.2	8.8	Ch,	3345.3	9.7	Jp,	3345.3	9.7	Dp,
	3352.5	10.5	O,	3355.6	10.0	B,	3366.5	10.9	Pt,	3372.5	11.0	Ca,
	3378.5	11.0	Gd.									
190907 TY AQUILAE—												
	3369.5	10.3	Pt.									
190925 S LYRAE—												
	3345.3	14.5	L.									
190926 X LYRAE—												
	3369.5	9.0	Pt.									
190933a RS LYRAE—												
	3313.2	11.6	Ch,	3338.7	10.3	Lv,	3357.6	10.0	Lv,	3369.5	10.5	Pt,
	3375.6	10.8	Jd.									
190941 RU LYRAE—												
	3325.4	12.3	Jp,	3325.4	12.1	Dp,	3345.3	11.1	Jp,	3345.3	11.0	Dp,
	3348.6	11.2	Pc,	3369.5	11.0	Pt,	3375.6	11.0	Jd.			
190967 U DRACONIS—												
	3350.5	11.7	O,	3356.6	11.9	Br,	3358.6	11.0	Ya,	3369.5	10.6	Pt,
	3369.6	10.9	Hu.									
191007 W AQUILAE—												
	3315.2	11.6	Ch,	3348.5	10.0	M,	3369.5	8.6	Pt.			
191017 T SAGITTARII—												
	3289.1	10.8	Ch,	3314.2	11.5	Ch,	3349.6	11.8	Y.			
191019 R SAGITTARII—												
	3280.1	9.4	Ch,	3314.2	11.4	Ch,	3335.2	10.6	Jp,	3335.2	10.6	Dp,
	3369.5	12.5	Pt.									
191033 RY SAGITTARII—												
	3280.1	9.5	Ch,	3296.1	9.4	Ch,	3305.1	8.9	Ch,	3341.2	11.5	L,
	3348.5	<12.0	Pt,	3351.5	<11.0	Pt,	3353.5	<10.0	Pt,	3355.5	<9.0	Pt,
	3357.5	<9.0	Pt,	3359.5	<9.0	Pt,	3363.5	<9.0	Pt,	3365.5	<13.0	Pt,
	3366.5	<12.0	Pt,	3375.5	<11.0	Pt.						
191319 S SAGITTARII—												
	3335.2	12.1	Jp,	3335.2	12.2	Dp,	3345.3	12.0	Gi,	3349.6	12.4	Y.
	3369.5	10.1	Pt,	3372.4	10.0	Ca.						
191321 Z SAGITTARII—												
	3345.3	13.9	Gi.									
191350 TZ CYGNI—												
	3345.4	10.3	Jp,	3345.4	10.3	Dp,	3369.5	9.9	Pt.			
191637 U LYRAE—												
	3333.3	9.2	Jp,	3333.3	9.3	Dp,	3345.4	9.7	Jp,	3345.4	9.7	Dp,
	3369.5	8.9	Pt.									
191717 T SAGITTAE—												
	3241.1	9.8	Nk.									
192928 TY CYGNI—												
	3282.1	12.2	Ch,	3312.2	11.6	Ch,	3350.5	10.4	O,	3369.5	9.3	Pt.
193311 RT AQUILAE—												
	3282.1	10.0	Ch,	3308.2	10.1	Ch,	3352.5	11.7	O,	3369.5	12.6	Pt.
193449 R CYGNI—												
	3281.1	9.8	Ch,	3292.2	10.0	Ch,	3315.2	11.1	Ch,	3333.3	11.2	Jp,
	3333.3	11.1	Dp,	3338.7	11.3	Lv,	3345.4	11.5	Jp,	3345.4	11.5	Dp,
	3348.5	12.1	Jd,	3348.6	11.5	Pc,	3352.6	10.9	Hu,	3357.6	12.0	Lv,
	3369.5	12.5	Pt,	3369.6	12.1	Pc,	3369.6	12.5	B.			
193509 RV AQUILAE—												
	3334.4	<12.5	Jp,	3345.4	<13.0	Jp,	3369.5	12.4	Pt.			
193732 TT CYGNI—												
	3352.6	7.5	Hu.									
194048 RT CYGNI—												
	3281.2	6.8	Ch,	3292.2	6.9	Ch,	3315.2	8.1	Ch,	3340.5	9.2	Gi,
	3347.8	9.8	Sg,	3349.7	9.7	Pc,	3352.6	10.5	Hu,	3369.5	11.8	Pt,
	3369.6	11.7	B,	3370.7	9.2	Sg,	3372.5	9.4	O.			

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Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
194348 TU CYGNI—												
	3281.2	10.4	Ch.,	3292.2	11.3	Ch.,	3315.2	12.4	Ch.,	3334.4	<12.4	Jp.
	3345.4	<12.7	Jp.,	3349.7	<13.0	Pc.,	3369.5	13.5	Pt.			
194604 X AQUILAE—												
	3344.7	14.1	Wf.,	3369.5	13.5	Pt.,	3369.7	13.0	Wf.			
194632 χ CYGNI—												
	3278.1	7.8	Ch.,	3287.1	6.3	Ch.,	3293.2	5.6	Ch.,	3299.0	4.9	Nk.,
	3305.2	5.3	Ch.,	3309.0	5.0	Nk.,	3310.0	4.9	Nk.,	3311.0	4.9	Nk.,
	3311.2	5.2	Ch.,	3313.1	5.0	Nk.,	3314.0	4.9	Nk.,	3319.1	5.0	Kd.,
	3319.2	4.9	Ch.,	3321.9	5.0	Kd.,	3322.9	5.0	Kd.,	3326.0	5.2	Kd.,
	3332.9	5.2	Kd.,	3335.9	4.9	Kd.,	3337.9	4.9	Kd.,	3339.0	4.9	Kd.,
	3340.0	5.0	Kd.,	3340.9	4.9	Kd.,	3341.3	4.9	An.,	3342.4	4.9	An.,
	3342.9	5.0	Kd.,	3344.1	5.0	Kd.,	3345.3	5.1	An.,	3348.0	5.0	Kd.,
	3348.5	4.5	Jd.,	3349.0	5.1	Kd.,	3349.9	5.2	Kd.,	3350.6	5.4	Ct.,
	3351.6	5.5	Ct.,	3352.5	4.8	O.,	3352.6	4.9	Hu.,	3355.6	5.4	Ca.,
	3355.6	5.7	Ct.,	3356.6	5.5	Ct.,	3358.2	5.3	An.,	3358.6	5.8	Ct.,
	3359.6	5.8	Ct.,	3360.6	5.7	Ct.,	3360.7	5.5	Br.,	3361.6	5.9	Ct.,
	3363.6	5.9	Ct.,	3364.7	5.9	Ct.,	3367.8	5.8	Ct.,	3368.5	4.8	O.,
	3368.6	5.6	Ca.,	3368.6	5.7	Ct.,	3369.5	6.0	Pt.,	3369.7	5.8	Ct.,
	3370.6	6.0	Ct.,	3371.6	6.1	Ct.,	3372.5	5.7	Ca.,	3372.6	6.5	Ct.
	3375.6	6.4	Ya.,	3376.6	6.4	Ct.,	3378.6	6.0	M.			
195302 RR AQUILAE—												
	3333.3	12.3	Jp.,	3333.3	12.2	Dp.,	3345.4	12.4	Jp.,	3345.4	12.4	Dp.,
	3349.6	11.8	Y.,	3367.6	12.8	B.,	3369.5	13.6	Pt.			
195308 RS AQUILAE—												
	3345.4	10.7	Jp.,	3345.4	10.5	Dp.,	3352.6	11.5	B.			
195653 NOVA CYGNI #3—												
	3281.2	10.2	Ch.,	3317.3	10.6	Ch.,	3333.3	11.3	Jp.,	3333.3	11.2	Dp.,
	3341.3	10.5	L.,	3345.4	11.1	Jp.,	3345.4	11.3	Dp.,	3348.5	10.8	Pt.,
	3348.6	10.7	M.,	3349.6	10.8	Jd.,	3354.5	10.5	Pt.,	3355.3	10.4	Ro.,
	3359.5	10.8	Pt.,	3363.5	10.8	Pt.,	3366.5	10.5	Pt.,	3367.3	10.5	Ro.,
	3369.5	10.8	Pt.,	3369.6	10.7	B.,	3371.5	10.0	Ca.,	3375.5	10.9	Pt.,
	3376.5	10.6	Ya.									
195849 Z CYGNI—												
	3281.2	11.8	Ch.,	3344.7	14.1	Wf.,	3369.6	12.5	Pt.,	3369.7	14.2	Wf.
200212 SY AQUILAE—												
	3341.3	13.0	L.,	3344.7	14.1	Wf.,	3349.6	13.0	Y.,	3369.6	13.0	Pt.,
	3370.7	13.9	Wf.									
200357 S CYGNI—												
	3344.7	<14.3	Wf.,	3369.7	14.3	Wf.						
200514 R CAPRICORNI—												
	3342.5	12.5	Lv.,	3349.6	12.3	Pc.,	3367.5	12.4	B.			
200647 SV CYGNI—												
	3241.0	10.1	Nk.,	3246.0	9.1	Nk.,	3259.1	9.3	Nk.,	3263.1	9.3	Nk.,
	3267.2	9.2	Nk.,	3299.0	9.0	Nk.,	3309.1	9.0	Nk.,	3347.6	8.6	M.,
	3352.6	8.5	Hu.									
200715a S AQUILAE—												
	3323.3	9.3	Jp.,	3323.3	9.3	Dp.,	3342.7	9.4	Wf.,	3348.6	9.1	M.,
	3349.3	9.2	Gi.,	3352.6	9.6	Ya.,	3352.6	9.7	B.,	3360.6	9.4	Wf.,
	3369.6	9.6	Pt.,	3370.5	9.5	Gd.,	3370.6	9.4	Wf.			
200715b RW AQUILAE—												
	3348.6	8.7	M.,	3352.6	8.9	Ya.,	3352.7	9.2	B.,	3369.6	9.2	Pt.
200812 RU AQUILAE—												
	3338.7	13.1	Lv.,	3344.7	13.9	Wf.,	3370.7	<13.6	Wf.			
200906 Z AQUILAE—												
	3323.3	11.3	Jp.,	3323.3	11.1	Dp.,	3349.3	13.6	Gi.,	3369.6	13.3	Pt.
200916 R SAGITTAE—												
	3348.6	9.6	M.,	3352.6	9.2	Ya.						

VARIABLE STAR OBSERVATIONS, October 20 to November 20, 1922—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
200938 RS CYGNI—												
	3293.1	8.1	Ch,	3317.3	7.3	Ch,	3341.3	7.9	L,	3352.7	7.0	Sg,
	3364.5	8.4	M,	3364.5	8.4	Gd,	3369.6	7.1	Pt,	3370.7	7.3	Sg,
	3376.6	7.8	Ya,	3378.6	8.4	M.						
201008 R DELPHINI—												
	3333.4	11.3	Jp,	3333.4	11.4	Dp,	3341.6	11.6	Wf,	3342.6	12.0	Br,
	3345.3	12.1	L,	3349.6	11.8	Y,	3367.6	12.6	B,	3369.6	12.8	Pt.
201121b RT CAPRICORNI—												
	3321.9	7.5	Kd,	3335.9	7.5	Kd,	3337.9	7.5	Kd,	3340.9	7.5	Kd,
	3344.4	7.0	L,	3369.6	6.5	Pt.						
201130 SX CYGNI—												
	3344.7	14.1	Wf.									
201119 RT SAGITTARII—												
	3366.5	10.6	Pt.									
201437b WX CYGNI—												
	3323.3	10.4	Jp,	3323.3	10.4	Dp,	3333.7	10.5	Lv,	3337.6	10.8	Lv,
	3342.7	10.7	Wf,	3345.4	10.5	Jp,	3345.4	10.5	Dp,	3348.6	11.2	Lv,
	3352.7	10.5	Sg,	3357.6	11.0	Lv,	3360.6	10.8	Wf,	3369.6	11.0	Pt,
	3370.7	11.1	Sg,	3378.6	11.2	M.						
201647 U CYGNI—												
	3241.0	7.9	Nk,	3246.0	7.8	Nk,	3259.1	8.6	Nk,	3267.2	9.1	Nk,
	3299.0	10.1	Nk,	3309.1	10.3	Nk,	3333.4	9.1	Jp,	3333.4	9.1	Dp,
	3342.6	10.0	Br,	3344.5	9.7	Gi,	3345.4	9.9	Jp,	3345.4	9.9	Dp,
	3347.6	11.2	M,	3349.6	9.8	Jd,	3352.7	10.2	Sg,	3352.7	10.9	Lc,
	3355.3	11.2	Ro,	3358.6	10.5	Ya,	3369.6	10.1	B,	3369.6	11.3	Pt,
	3370.7	11.0	Sg,	3372.6	10.2	Jd.						
202539 RW CYGNI—												
	3347.6	8.6	M,	3378.6	8.5	M.						
202817 Z DELPHINI—												
	3344.7	14.2	Wf.									
202946 SZ CYGNI—												
	3347.6	9.0	M,	3348.6	8.8	Pt,	3369.6	9.8	Pt.			
202954 ST CYGNI—												
	3333.4	12.6	Jp,	3344.7	13.4	Wf,	3370.6	13.0	B,	3378.6	12.6	M.
203226 V VULPECULAE—												
	3347.6	8.7	M,	3369.6	9.2	Pt.						
203611 Y DELPHINI—												
	3344.7	13.3	Wf.									
203816 S DELPHINI—												
	3241.1	11.1	Nk,	3247.1	11.1	Nk,	3256.0	11.2	Nk,	3259.1	11.2	Nk,
	3267.0	10.5	Nk,	3309.1	10.3	Nk,	3311.0	10.2	Nk,	3322.0	9.0	Nk,
	3366.6	8.8	B,	3369.5	9.0	Ya,	3378.6	9.0	M.			
203847 V CYGNI—												
	3279.1	9.7	Ch,	3289.1	9.2	Ch,	3306.1	8.5	Ch,	3333.4	8.0	Jp,
	3333.4	8.0	Dp,	3333.7	8.5	Lv,	3338.7	9.0	Lv,	3342.7	9.0	Br,
	3343.7	8.4	Wf,	3344.5	7.8	Gi,	3369.6	7.7	Pt,	3369.6	8.2	B,
	3376.6	9.0	Ya,	3378.6	8.7	M.						
203905 Y AQUARII—												
	3333.4	11.2	Jp,	3333.4	11.1	Dp,	3348.6	11.7	Pc,	3349.6	11.7	B,
	3369.6	12.1	Pt.									
204016 T DELPHINI—												
	3341.6	11.7	Wf,	3342.7	11.8	Br,	3352.6	10.4	B,	3352.7	10.8	Sg,
	3369.6	9.5	Pt,	3370.7	9.4	Sg,	3378.6	9.3	M.			
204017 U DELPHINI—												
	3241.2	6.5	Nk,	3249.2	6.8	Nk,	3252.1	6.5	Nk,	3256.1	6.5	Nk,
	3260.1	6.5	Nk,	3262.1	6.5	Nk,	3263.1	6.5	Nk,	3267.0	6.8	Nk.
204102 V AQUARII—												
	3242.7	8.3	Br,	3252.6	8.6	B,	3269.6	8.4	Pt.			
204104 W AQUARII—												
	3267.2	12.2	Nk,	3311.0	12.0	Nk,	3333.4	<12.4	Dp,	3345.3	12.5	L.

VARIABLE STAR OBSERVATIONS. October 20 to November 20, 1922—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
204215 U CAPRICORNI—												
	3323.3	12.2	Jp,	3323.3	12.3	Dp,	3349.6	14.0	Pc.	3367.5	14.0	B.
204318 V DELPHINI—												
	3341.6	<14.1	Wf.									
204405 T AQUARII—												
	3258.1	<11.6	Ch,	3313.2	11.6	Ch.	3323.3	10.2	Jp.	3323.3	10.1	Dp,
	3342.7	9.3	Br,	3349.7	8.0	Sg.	3350.6	8.8	Ct.	3351.6	8.5	Ct.
	3352.6	7.7	B,	3361.6	7.6	Ct,	3363.6	7.7	Ct,	3367.6	7.6	Ct.
	3368.6	7.6	Ct,	3369.6	7.5	Pt,	3370.6	7.6	Ct,	3370.7	7.6	Sg.
	3371.6	7.6	Ct,	3372.5	7.6	Ca,	3372.6	7.8	Ct.	3373.6	7.0	M,
	3375.6	7.5	Ya,	3376.6	7.8	Ct.						
204846 RZ CYGNI—												
	3338.7	13.2	Lv,	3340.5	13.7	Gi,	3344.7	13.7	Wf,	3348.6	13.1	Lv,
	3369.6	13.9	Pt.									
205017 X DELPHINI—												
	3338.6	12.3	Lv,	3341.6	12.0	Wf.	3345.6	12.5	Lv,	3345.6	12.2	Cn.
	3345.6	12.6	Ce.	3348.5	12.6	M,	3348.6	12.5	Lv.	3357.6	12.5	Lv,
	3367.6	13.0	B.									
205017 — DELPHINI—												
	3338.6	12.7	Lv,	3345.6	12.9	Lv,	3348.5	12.8	M,	3348.6	12.6	Lv.
	3357.6	12.6	Lv.									
205923 R VULPECULAE—												
	3323.3	8.8	Jp,	3323.3	8.8	Dp,	3340.5	9.2	Gi,	3341.7	9.3	Lv,
	3342.7	9.3	Wf,	3352.6	9.6	Hu,	3360.6	10.8	Wf,	3369.6	11.6	Pt.
	3373.5	11.7	B.									
210116 RS CAPRICORNI—												
	3263.1	7.9	Nk,	3267.2	7.8	Nk,	3309.1	8.3	Nk.			
210124 V CAPRICORNI—												
	3323.4	10.0	Jp,	3323.4	10.2	Dp.						
210129 TW CYGNI—												
	3344.7	12.7	Wf.	3348.6	12.0	Y,	3370.6	12.4	Br,	3370.6	12.2	B.
210221 X CAPRICORNI—												
	3285.2	11.2	Nk.									
210382 X CEPHEI—												
	3341.7	<13.4	Wf.									
210504 RS AQUARII—												
	3323.4	12.9	Jp,	3323.4	12.8	Dp,	3345.3	13.8	L,	3348.6	13.7	Pc.
	3373.6	<13.4	B.									
210516 Z CAPRICORNI—												
	3352.6	11.0	B,	3369.6	12.2	Pt.						
210812 R EQUULEI—												
	3344.7	13.2	Wf,	3370.6	10.8	Br.						
210868 T CEPHEI—												
	3293.1	9.2	Ch,	3311.1	9.5	Ch,	3319.0	9.5	Jk,	3341.0	<10.1	Jk,
	3341.3	10.4	L,	3358.6	10.3	Ya.	3369.6	10.3	Pt.	3371.7	10.2	Ca.
	3372.7	9.9	Sg,	3374.6	9.8	B.						
210903 RR AQUARII—												
	3323.4	9.4	Jp,	3323.4	9.4	Dp,	3348.6	10.0	M,	3352.6	10.8	B,
	3369.6	11.8	Pt.	3370.6	11.5	Br.						
211614 X PEGASI—												
	3323.4	11.2	Jp,	3323.4	11.2	Dp.	3341.5	10.9	Gi,	3342.7	10.5	Wf.
	3342.8	10.1	Br,	3348.6	10.6	M,	3369.6	9.5	Pc,	3369.6	9.7	Pt,
	3369.6	9.6	B,	3370.6	9.7	Br.						
211615 T CAPRICORNI—												
	3352.6	9.6	B.									
212814 Y CAPRICORNI—												
	3323.4	12.8	Jp.	3323.4	12.8	Dp.	3367.6	12.8	B.			
213244 W CYGNI—												
	3241.1	6.4	Nk.	3242.0	6.3	Nk.	3246.0	5.5	Nk.	3252.1	6.2	Nk,
	3257.1	6.3	Nk,	3259.0	6.2	Nk,	3260.1	6.4	Nk,	3262.0	6.3	Nk.

VARIABLE STAR OBSERVATIONS, October 20 to November 20, 1922—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
213244 W CYGNI—Continued												
	3263.1	6.6	Nk,	3264.0	6.6	Nk,	3267.0	6.5	Nk,	3299.0	6.4	Nk,
	3301.1	5.9	Nk,	3309.1	6.4	Nk,	3310.0	6.3	Nk,	3311.0	6.4	Nk,
	3319.1	6.5	Kd,	3321.9	6.5	Kd,	3335.9	6.4	Kd,	3339.0	6.5	Kd,
	3340.9	6.5	Kd,	3341.3	5.6	L,	3341.3	6.5	An,	3342.9	6.5	Kd,
	3348.0	6.6	Kd,	3350.0	6.5	Kd,	3358.2	6.6	An.			
213678 S CEPHEI—												
	3338.8	8.0	Lv,	3341.7	8.0	Wf,	3342.8	8.0	Br,	3347.6	8.4	M,
	3358.6	8.0	Ya,	3369.6	7.2	Pt,	3369.6	8.0	Hu,	3374.6	7.2	B.
213753 RU CYGNI—												
	3347.6	8.0	M,	3369.6	8.1	Pt.						
213843 SS CYGNI—												
	3219.1	<10.0	Jk,	3221.1	<11.3	Jk,	3229.1	9.7	Jk,	3229.1	9.5	Jk,
	3229.1	9.4	Jk,	3229.2	9.1	Jk,	3230.0	8.3	Jk,	3241.9	8.3	Nk,
	3242.0	9.2	Nk,	3242.1	9.2	Nk,	3246.1	10.7	Nk,	3247.0	11.2	Nk,
	3248.0	11.4	Nk,	3256.0	12.0	Nk,	3257.0	12.0	Nk,	3258.0	12.0	Nk,
	3265.2	11.9	Ch,	3267.0	12.0	Nk,	3280.2	11.7	Ch,	3287.1	11.8	Ch,
	3292.1	12.0	Ch,	3296.1	11.9	Ch,	3298.1	11.9	Ch,	3305.1	11.6	Ch,
	3306.1	8.3	Ch,	3307.1	8.2	Ch,	3309.0	8.4	Nk,	3310.0	8.7	Nk,
	3310.1	8.3	Ch,	3310.9	9.1	Nk,	3311.0	9.2	Nk,	3312.1	9.2	Ch,
	3313.0	9.9	Nk,	3313.2	9.8	Ch,	3314.2	10.5	Ch,	3315.2	11.0	Ch,
	3315.9	11.6	Nk,	3317.2	11.9	Ch,	3318.9	11.7	Nk,	3319.0	<10.9	Jk,
	3321.9	11.9	Nk,	3323.4	11.9	Jp,	3323.4	12.0	Dp,	3325.4	12.1	Jp,
	3325.4	12.1	Dp,	3329.6	11.8	L,	3333.4	12.0	Jp,	3333.4	12.0	Dp,
	3338.7	11.0	Lv,	3338.8	10.9	Lv,	3340.5	10.3	Gi,	3340.6	10.7	Lv,
	3340.7	10.2	Wf,	3340.9	10.4	Jk,	3341.0	10.0	Jk,	3341.3	10.0	L,
	3341.4	10.2	Gi,	3341.6	10.0	Lv,	3341.7	9.8	Lv,	3341.7	10.0	Wf,
	3342.3	9.6	L,	3342.5	10.0	Lv,	3342.6	9.9	Br,	3342.7	10.0	Wf,
	3342.8	9.9	Br,	3343.4	9.7	Gi,	3343.7	9.6	Wf,	3344.4	9.1	L,
	3344.5	9.5	Gi,	3344.7	8.9	Wf,	3345.2	8.9	L,	3345.3	9.2	Jp,
	3345.3	9.2	Dp,	3345.4	9.2	Jp,	3345.4	9.1	Dp,	3345.6	9.3	Lv,
	3345.6	9.4	Cn,	3345.6	9.6	Ce,	3345.7	8.8	Wf,	3346.2	8.9	Jp,
	3346.2	8.8	Dp,	3346.6	8.6	Lv,	3346.6	8.8	Jh,	3346.6	8.8	Kr,
	3347.3	9.1	Jp,	3347.3	9.0	Dp,	3347.6	8.5	M,	3347.6	8.5	Lv,
	3348.3	8.5	Jp,	3348.3	8.4	Dp,	3348.5	8.3	Gd,	3348.6	8.3	M,
	3348.6	8.6	Pt,	3348.6	8.3	Lv,	3348.6	8.7	Y,	3349.4	8.8	Jp,
	3349.4	8.7	Dp,	3349.5	8.7	Pt,	3349.6	8.3	Pc,	3349.6	8.8	Jd,
	3349.6	8.3	Lv,	3349.6	8.8	Y,	3349.7	8.4	B,	3351.2	8.9	Jp,
	3351.2	8.8	Dp,	3351.5	8.3	Pt,	3351.7	8.5	Sg,	3352 6	8.4	Lv,
	3352.6	8.9	Hu,	3352.7	8.6	B,	3353.4	9.0	Jp,	3353.4	8.9	Dp,
	3353.5	8.8	Pt,	3353.7	8.4	Lv,	3354.5	8.7	Pt,	3354.6	8.6	Lv,
	3355.3	8.7	Ro,	3355.5	9.2	Pt,	3356.5	9.2	Pt,	3356.6	8.9	Br,
	3356.6	9.4	O	3356.6	9.5	Gd,	3357.5	9.5	Gd,	3357.5	9.5	O,
	3357.5	9.5	Pt,	3357.6	9.6	Lv,	3358.5	9.6	Gd,	3358.5	9.6	O,
	3358.5	9.8	Pt,	3358.6	9.8	Ya,	3359.5	10.4	Gd,	3359.5	10.4	Pt,
	3359.6	10.2	Ya,	3359.7	10.2	Wf	3360.6	10.3	Wf,	3361.6	11.7	Br,
	3363.5	11.9	Pt,	3364.3	11.5	Ro,	3364.5	11.7	Gd,	3364.5	11.7	M,
	3365.5	11.8	Pt,	3366.5	11.7	Pt,	3368.6	11.9	Ca,	3369.6	11.9	B,
	3369.6	11.6	Pc,	3369.6	11.6	Pt,	3369.7	11.8	Wf,	3369.8	11.7	Sg,
	3370.5	11.8	Jd,	3370.6	11.8	Br,	3370.6	11.7	B,	3370.7	11.9	Wf,
	3371.7	11.9	Ca,	3372.6	<11.8	Jd,	3373.7	11.6	B,	3374.7	11.7	B,
	3375.5	11.9	Gd,	3375.5	11.6	Pt,	3375.6	11.8	Jd,	3376.5	<11.3	Ya,
	3376.5	11.7	Pt,	3378.6	12.0	M.						
213937 RV CYGNI—												
	3347.6	8.0	M	3352.6	7.5	Hu,	3369.6	6.6	Pt.			
214024 RR PEGASI—												
	3341.7	11.0	Wf,	3342.8	10.6	Br,	3348.6	10.0	M,	3356.6	9.3	Gd,
	3356.6	9.3	O,	3370.6	9.0	B,	3369.6	9.1	Pt,	3370.7	9.0	Br,
215605 Y PEGASI—												
	3341.7	9.1	WF,	3341.7	9.0	Lv,	3342.8	9.4	Br,	3348.6	9.8	M,
	3369.6	10.0	Pt,	3369.7	9.7	B.						

VARIABLE STAR OBSERVATIONS. October 20 to November 20, 1922—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
215717 U AQUARII—												
	3352.6	12.1	B,	3375.5	11.0	Pt.						
215934 RT PEGASI—												
	3341.7	13.5	Lv.	3342.8	11.3	Br.	3348.6	11.1	M.	3348.6	11.0	Y.
	3356.6	10.9	Gd.	3356.6	10.9	O.	3357.6	12.8	Lv.	3369.6	10.6	Pt.
	3370.7	10.5	Br.	3370.7	11.9	B.	3372.7	11.0	Sg.			
220133a RY PEGASI—												
	3370.7	7.6	B.									
220133b RZ PEGASI—												
	3375.5	7.6	Pt.									
220412 T PEGASI—												
	3345.4	14.0	L.									
220613 Y PEGASI—												
	3344.5	14.2	Gi.	3374.6	11.0	B.						
220714 RS PEGASI—												
	3329.7	10.9	Lv.	3341.7	11.2	Lv.	3344.5	11.0	Gi.	3352.5	11.3	O.
	3356.6	11.5	Br.	3357.6	11.4	Lv.	3374.6	11.8	B.			
222129 RV PEGASI—												
	3374.7	12.3	B.									
222439 S LACERTAE—												
	3329.6	12.6	L.	3340.5	11.8	Gi.	3348.5	11.5	M.	3370.6	9.8	B.
	3375.5	9.4	Pt.									
223841 R LACERTAE—												
	3329.6	13.9	L.									
225120 S AQUARII—												
	3369.5	9.5	B.									
225914 RW PEGASI—												
	3348.8	10.8	Sg.	3349.5	10.5	O.	3356.7	10.4	Br.	3370.6	9.6	B,
	3372.7	9.8	Sg.									
230110 R PEGASI—												
	3375.5	13.0	Pt.									
230759 V CASSIOPEIAE—												
	3340.7	7.9	Gi.	3349.4	7.8	Jp.	3349.4	7.8	Dp.	3350.7	8.4	Sg.
	3353.5	8.1	Pt.	3355.3	8.3	Ro.	3360.6	8.5	B.	3364.3	9.0	Ro.
	3367.3	9.3	Ro.	3369.6	8.6	Hu.	3372.7	9.3	Sg.			
231425 W PEGASI—												
	3329.6	10.6	L.	3338.8	10.8	Lv.	3348.7	10.6	Lv.	3357.7	10.6	Lv.
231508 S PEGASI—												
	3353.5	12.0	Pt.	3374.7	12.3	B.						
232848 Z ANDROMEDAE—												
	3267.1	9.8	Nk.	3309.1	10.0	Nk.						
233335 ST ANDROMEDAE—												
	3281.2	11.2	Ch.	3298.1	10.8	Ch.	3309.1	10.8	Nk.	3311.1	10.3	Ch.
	3344.7	9.7	Wf.	3350.5	9.8	O.	3352.6	9.2	Hu.	3353.5	9.0	Pt.
	3356.7	9.6	Br.	3374.7	9.1	B.						
233815 R AQUARII—												
	3281.2	10.2	Ch.	3297.2	9.7	Ch.	3311.2	9.7	Ch.	3353.5	9.3	Pt.
	3368.6	9.1	Ca.	3375.6	9.5	Ya.						
233956 Z CASSIOPEIAE—												
	3344.7	14.2	Wf.									
235053 RR CASSIOPEIAE—												
	3340.6	11.4	Gi.	3360.5	11.3	B.						
235209 V CETI—												
	3345.3	14.1	L.									
235350 R CASSIOPEIAE—												
	3340.6	10.2	Gi.	3360.6	7.9	B.	3369.6	7.9	Hu.			
235525 Z PEGASI—												
	3267.1	12.5	Nk.	3311.0	<13.0	Nk.	3353.5	13.0	Pt.			
235939 SV ANDROMEDAE—												
	3353.5	12.2	Pt.	3359.5	12.3	Gd.						

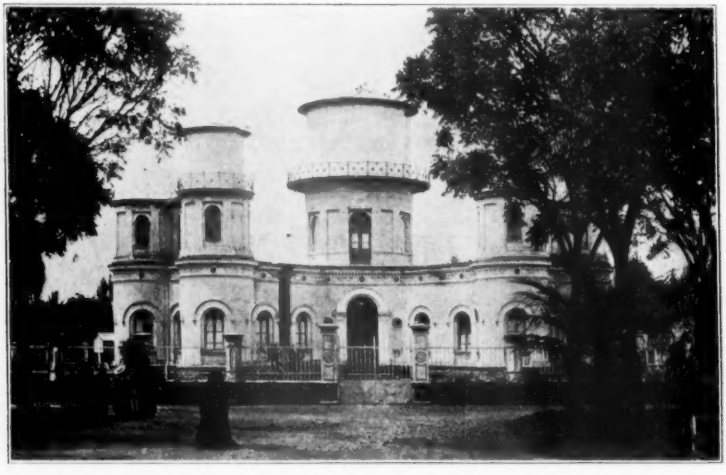
Total Observations: 1,688. Stars Observed: 276. Observers: 33.

COMMUNICATION.

"An Observatory on the Equator."— In the August-September (1922) number of POPULAR ASTRONOMY an article by James H. Worthington under the above title was published. The attention of Lieutenant-Colonel Georges Perrier, Secretary of the section of Geodesy of the International Geodedic and Geophysical Union, was attracted to this article and in reply he has furnished the following communication and photograph which will be of interest to our readers. Mr. Perrier writes from personal knowledge concerning the observatory he describes.

THE OBSERVATORY OF QUITO.

The Observatory of Quito was built during the interval from 1870 to 1875 on the initiative of the celebrated president Garcia Moreno and was directed at first by Father Menten, one of the German Jesuits called to Equador by the president. It was equipped in the first place with instruments of German manufacture, (a 9-inch equatorial of Merz, a 6-inch meridan circle of Repsold, a large universal instrument of Pistor and Martins, Densker's clocks, etc.).



THE OBSERVATORY OF QUITO.

The work of the Observatory was directed from 1900 to 1906 by M. Gonnessiat, now director of the Observatory of Algiers; from 1906-1907 by M. Lagrula, at present an astronomer in the Observatory of Nice. That was the period when the French geodetic commission, entrusted with the measurement of the new meridian arc of Quito, was working in Equador and Peru. The Observatory is an important point of the geodetic system of the meridian arc. It has been the origin of a great number of determinations of differences in longitude. Its importance has been appreciably increased, because to the astronomical studies have been added others, meteorological, actinometric, seismographic, magnetic, etc.

Position: Latitude: 0° 14′ 0″ South; Longitude: 5^h 15^m 20^s West of Greenwich.

GENERAL NOTES.

Mr. R. T. A. Innes, the union astronomer at Johannesburg, has received the degree of doctor of science from the University of Leyden.—*Science*, Dec. 1.

The Irving Porter Church Telescope of the Fuertes Observatory, Cornell University, Ithaca, New York, has recently been completed, and is now in use regularly by Dr. Samuel L. Boothroyd, the director of the observatory. The telescope is a 12-inch equatorial refractor. The mounting for it was made by Warner and Swasey and embodies the most modern improvements now furnished by this firm which has had such extensive experience in work of this kind. The lens also has been found to be of excellent quality. It is planned to hold appropriate dedicatory exercises in the spring after certain improvements on the building have been completed.

A Copernicus Memorial.—A circular signed by Jan Krassowski, Professor of Astronomy, and Stanislaw Kalinowski, Rector of the Free University of Poland, calls attention to the fact that February 19, 1923, is the 450th anniversary of the birth of Copernicus. It states that a grant of land has been obtained by this university upon which it is planned to erect an observatory "which is to commemorate for future generations, our free and independent country's gratitude to Nicholas Copernicus." An appeal is made for assistance to carry out this project. Contributions in money, in instruments or in books and astronomical periodicals will be gratefully received. All communications should be addressed to the Rector of the Free University of Poland, Sniadeckich 8, Warsaw (Wolna Wszechnica Polska, Warsawa, Sniadeckich 8). —(*Publications of the A. S. P.*, December, 1922).

Reported Nova in Lyra.—A cablegram received at the Harvard Observatory, December 4, from the Central Bureau in Copenhagen, announced the discovery on December 1 by Zwierel, in Roumania, of a nova of the first magnitude, in right ascension $18^h\ 48^m$, declination $+28°$.

A photograph made at the Harvard Observatory on the night of November 28 shows no star as bright as 11.5 in the position given, and photographs made December 4 also fail to show a nova in this vicinity.

Harvard College Observatory, Bulletin 780,

Cambridge, Massachusetts, December 5, 1922.

NOTE.—Because of clouds, the region of the sky in which the nova was reported to be could not be seen in Northfield until December 8. No object could be found which in any way corresponded to the description of the nova.

Atmosphere of Venus.—A letter received November 28, from Professor John C. Duncan, Director of the Whitin Observatory, Wellesley, Massachusetts, contains the following statement concerning observations of Venus made near the time of inferior conjunction:

"The luminous effect of the atmosphere of Venus was observed here with the 12-inch refractor on the mornings of November 23 and 24, 1922. On the earlier date the horns of the crescent extended distinctly beyond the ends of a diameter, while on the 24th the entire circle was easily seen by a number of persons, two of

whom were students who were not aware that any such appearance was to be expected. The planet was best seen when the objective was shaded from direct sunlight by a screen held in the opening of the dome, although in that position the screen covered about two-thirds of the diameter of the objective. At the time of the last observation the planet was about 2.5 degrees from the center of the sun. On both days the sky was unusually clear and the seeing poor."

Harvard College Observatory Bulletin 779.

Heliophysical Institute at Utrecht.— In *Bulletin of the Astronomical Institutes of the Netherlands* No. 20 Prof. W. H. Julius states: "In recent years a part of the Physical Laboratory of the University of Utrecht has gradually been adapted to studies in the domain of solar physics." He then describes a new vertical telescope with a Zeiss objective of 25 cm. aperture and 13 meters focal length which has been erected together with the spectrographic attachments. The solar beam is sent through the objective by means of the usual coelostat. Owing to the location of the university in a manufacturing center the tower support such as used at the Mt. Wilson Observatory would not be sufficiently stable. Accordingly it was decided to erect an addition to the physical laboratory of reinforced concrete of the requisite height and with ground dimensions of 7 x 4 meters in order to provide a rigid support for the vertical telescope and accessories. By means of an ingenious device the beam of light in the spectroheliograph can be divided into two parts and simultaneous spectroheliograms of the same portion of the solar disc can be made in light differing in wave-length by as much as 700 Å.

Absolute Magnitude of RZ Cephei.— In Harvard Bulletin 773 an investigation of the cluster variable RZ Cephei by the writer indicates that this star has a transverse velocity of approximately 1100 kilometers a second. The computation was based on measures of proper motion at Groningen and Harvard, on photometric investigations of the range and median magnitude at Harvard, and on the assumption that the photographic median absolute magnitude of the star is —0.2. The corresponding absolute magnitude at maximum is —0.6.

A letter from Dr. Bertil Lindblad, of the Observatory at Upsala, Sweden, states that a spectroscopic investigation of the absolute magnitude of RZ Cephei yields a value at maximum of —0.7, in close agreement with the assumed value. He writes: "The spectral type seems to be A0 at maximum, and about A3 at minimum. The hydrogen lines are decidedly sharp. The deduced absolute magnitude rests on the hypothesis that the conditions are comparable at the surface of the variable and the surfaces of ordinary A stars."

Harvard College Observatory Bulletin 778.

Cambridge, Massachusetts, November 13, 1922.

Hydrogen Emission in Class B Spectrum. — A comparison of early photographs with one made this year at Arequipa by Miss Cannon shows a remarkable change in the spectrum of the Class B star, H. R. 4830, magnitude 6.0, for which the position in 1900 was $12^h\,36^m.9$, $-62°\,30'$. It is well known that bright hydrogen lines have disappeared from the spectra of several Class B stars, such as Pleione, J Velorum, p Carinae, and μ Centauri; but the inverse process, the appearing of bright lines, or a decided increase in their brightness, has not hitherto been surely proved for stars of constant magnitude. The

spectrum of H. R. 4830 was photographed with the 13-inch Boyden telescope on May 14, 1922, exposure 55 minutes. Hβ and Hγ are strong emission lines, and Hδ also shows a trace of emission.

Earlier photographs of this spectrum were taken with the same instrument on May 31, 1906, and April 9, 1908, with exposures of 61 and 91 minutes, respectively. Although the spectrum was announced in Harvard Circular 124 as having Hβ and Hγ bright, the emission lines, if real, were then extremely faint, as described in Harvard Annals **56**, 153, Remark 100. The photograph of April 9, 1908, shows very wide hydrogen absorption lines without any trace of emission.

Harvard College Observatory Bulletin 779.

Variables of Spectral Class S.— In the course of a general discussion of photometric data concerning long period variable stars, Mr. Campbell has compared the properties of the variables of spectral Class S with those of other long period variable stars. The letter S was assigned by the Committee on Stellar Classifications of the International Astronomical Union to spectra found by Miss Cannon to resemble that of the star π^1 Gruis. Nearly all of these stars appear to be variable, and light curves for the following fifteen have been extensively studied.

Des.	Name	Des.	Name	Des.	Name
001046	X Andromedae	045307	R Orionis	081617	V Cancri
001838	R Andromedae	065355	R Lyncis	123961	S Ursae Majoris
004047	U Cassiopeiae	070122a	R Geminorum	142584	R Camelopardalis
011272	S Cassiopeiae	070310	R Canis Minoris	191017	T Sagittarii
043065	T Camelopardalis	074323	T Geminorum	193449	R Cygni

It is not certain that R Orionis should be included in this list.

In the following tabulation the fifteen variables of Class S are compared with one hundred and eleven variables of Classes M and N for which sufficient data are now available. Mr. Campbell's classification of the light curves into seven types is described in POPULAR ASTRONOMY **28**, 523, 1920. The light curves are more symmetrical on the average for the S variables than for the others, and none of the former are in the sixth and seventh types, which show the steepest rise to maximum brightness.

	Class S	Others
Average type of light curve	3.3	4.4
Mean period in days	357	307
Mean maximum magnitude	8.1	8.4
Mean minimum magnitude	13.2	13.1
Mean range	5.1	4.6
Mean galactic latitude	±21°	±32°

The most important differences between Class S stars and the others are longer period and greater range. The lower galactic latitude may indicate that the average absolute magnitude for Class S variables is greater than for the ordinary long period variable stars.

Harvard College Observatory Bulletin 778.

Cambridge, Massachusetts, November 13, 1922.

The Crocker Eclipse Expedition.—In response to our request, Professor W. W. Campbell, director of the Lick Observatory, has kindly contributed the following brief account of the expedition sent out to observe the Total Solar

Eclipse of September 21, 1922. The manuscript arrived just too late to be inserted in the December number of POPULAR ASTRONOMY.

The Crocker Eclipse Expedition from the Lick Observatory, University of California, selected Wallal, on the north-west coast of Australia, as the observing station, because of its evident advantages. The duration of totality at Wallal would be appreciably longer than at any other point on the path of totality; the eclipsed sun would be at a high altitude, 58 degrees above the horizon; and the weather observations of the preceding twenty-five years had indicated a very high degree of probability for clear sky on the afternoon of September 21. In the last twenty-five Septembers rain had fallen in that region only twice, and on each of the two occasions the precipitation was less than a tenth of an inch. Twenty-five Septembers amount to more than two years of time. Following the announcement that the Government of Australia, operating through the Royal Australian Navy, would transport our expedition from Fremantle, a splendid port near the south-west corner of the Commonwealth, to Wallal and back to Fremantle, and conduct the landing and embarking operations at Wallal, several other expeditions applied for permission to establish their stations at the same point and under the same auspices. The five accepted expeditions represented California, the University of Toronto, the Kodaikanal Observatory in Southern India, the Perth Observatory, and a private enterprise from the vicinity of Cambridge, England.

The landing at Wallal, for personnel and seventy tons of instruments and supplies, was made without special difficulty by means of a single life boat towed by a small motor launch from the anchored schooner into shallow water, whence the packages were conveyed to beyond high water mark by a group of forty or fifty aborigines. The embarking, in the days following the eclipse, was likewise made without special difficulty, save that a severe windstorm and its consequences delayed proceedings during two days and a half. When the wind and the waves died down, the eighty-ton schooner ran in at high tide nearly as far as it could go. The receding of the tide left the schooner high and dry. Donkey wagons drove alongside the schooner with the eclipse packages and the transferring of the last four-fifths of the freight was made in less than four hours.

Save as to the millions of flies which interfered with our comfort from sunrise to dark, and the clouds of impalpable dust which on several occasions floated through the camp, finding its way into driving clocks, plate holders and other mechanisms, and finally interfering very seriously with the development of the exposed plates, the conditions of air and sky were even better than we had anticipated. Every day from August 30, when we arrived, to September 24 had clear skies, and the eclipse day, September 21, was conceded by everyone to be the best day of all. This was true not only at Wallal, but at the station of the Adelaide party in Central Australia, and the stations of the Melbourne and Sydney parties in South-eastern Queensland.

The program of the Crocker expedition went through substantially as planned. Unfortunately, we developed some of the plates on the two nights following the eclipse, but desisted because the dust in the drying process threatened to ruin the plates pictorially if not scientifically. The undeveloped plates were taken to Broome, 180 miles north-easterly, where the development proceeded at night with freedom from dust, and with ice to control the temperature.

There was not time at any point en route to set up and use the powerful measuring microscope long enough to obtain complete series of measures of any

of the plates. Through circumstances beyond our control the 600 pounds of eclipse negatives with their packings could not be got around the west and south sides of Australia in time to join the observers at Sydney, and travel together to Mount Hamilton. The plates are expected to reach San Francisco in the first week of December, and Mount Hamilton before the middle of the month.

It is not wise to venture at this time a prediction as to when an announcement of scientific results will be made.

Although the work at Wallal was extremely arduous, all members of all the expeditions enjoyed perfect health.

It is my pleasing duty to say that the generosity and hospitality afforded by the Commonwealth Government, the Government of the States through which we passed, and by Universities, were on a scale probably never before exceeded under similar conditions. The interest taken in our plans by the Universities, the Royal Societies, and many other organizations, and by the newspapers and people in general, was likewise intense and inspiring.

Neue Methoden zur Untersuchung der Objective nebst Bemerkungen uber die Beurteilung ihrer Gute, Y. Väisälä, Annals of the Finnish University of Abo. This booklet of 130 pages brings together the more recent methods of testing objectives, giving both the theory as well as examples illustrating their applications. It is valuable to have the methods from various sources brought together and the author has thus performed a distinct service to all those interested in the testing of telescope objectives.

Grundriss der theoretischen Astronomie, Dr. J. Frischauf, 3rd edition, 246 pp. (Engelmann, Leipzig). This last edition of Dr. Frischauf's book is a good introduction to the study of theoretical astronomy. The classical methods of computing orbits as developed by Gauss and Olbers are followed for the most part, but the method developed by Gibbs is also given fair consideration. A few pages are devoted to Encke's method of computing special perturbations. Examples are given showing the way in which the formulae are to be used. An especially interesting part of the book is that portion which deals with the historical side of the subject. It begins with the methods of the ancients when they used the excentric circle and epicycles and shows how these are used for the determination of the latitude and longitude of a planet or of the sun. Then follow the work of Copernicus, Tycho Brahe, Kepler, and some of their successors. The portion dealing with Kepler goes into considerable detail, not only concerning his work but the reasons which led him to undertake it. An American may be pardoned if he feels a slight disappointment in not finding Leuschner's method of orbit determination mentioned. The reviewer questions the statement in the footnote on page 42, that 7-place logarithms *must* be used in orbit computation for short intervals of 5-15 days, in view of the inaccuracies of the places of comparison stars. Aside from these the book is good and can be recommended as an introductory course in orbit determination.

Verses to the Vassar Dome.

A low-built tower and olden,
Dingy but dear to the sight,
And they that dwell therein are wont
To watch the stars at night.

A wide and ample chamber,
Where a clock on marble pier
With low beat follows the stars that track
The slow-revolving year.

And all that dwell in that chamber
Or cross but its stone threshold,
Whether for use or knowledge,
All things in common hold.

And the winds are free of the casement,
And the sunlight streams on the floor,
And the vines come in at the windows,
And the birds build nests at the door.

Without, among the feathered grass,
The vine-dyed rose leaves fall,
And the golden robin's note is heard,
And the wood pewees call.

And they that scan the heavens by night,
Since truth's clear light they saw,
No human meets and measures serve,
But Nature's mightier law.

That law that works in wondrous way,
Where ebbing star drift rolls,—
In unseen solitary sway,
That lifts the tide of souls.

And whether with searching glass I scanned
Those far, deep lanes of night,
Where stars well up through endlessness
In springs of living light,

Or whether, by day, I wandered
The hills and dales along,
And heard the veery's wood-notes weird
And the thrushes' uplifting song,

In woodland wild or wind-blown dale
Far hid in the forest's girth,
Where the Sky-maiden once awandering
Strewed stars in the vales of earth,—

The treasures of earth and heaven,
I gathered and brought them home.
Those gifts of infinite Nature
Found place in that low room.

For a nameless light and freedom
Lifts the rude walls away,
And Nature blends with the spirit
In love's dissolving day.

So that tower, I find it thus ever
As I knew it in days gone by,
For Dome was over it never,
Beside the boundless sky.

1896.

ANTONIA C. MAURY.